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TRANSACTIONS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

HELD AT PHILADELPHIA,

FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XIII.—NEW SERIES.

PUBLISHED BY THE SOCIETY.

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1869.

EXTRACT

FROM THE LAWS OF THE SOCIETY RELATING TO THE TRANSACTIONS.

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1. Every communication to the Society which may be considered as intended for a place in the Transactions, shall immediately be referred to a committee to consider and report thereon.

2. If the committee shall report in favor of publishing the communication, they shall make such corrections therein as they may judge necessary to fit it for the press; or, if they shall judge the publication of an abstract or extracts from the paper to be more eligible, they shall accompany their report with such abstract or extracts. But if the author do not approve of the corrections, abstract, or extracts reported by the committee, he shall be at liberty to withdraw his paper.

3. Communications not intended by their authors for publication in the Transactions, will be received by the Society, and the title or subject of them recorded; and, if they be in writing, they shall be filed by the secretaries.

4. The Transactions shall be published in numbers, at as short intervals as practicable, under the direction of the Committee of Publication, and in such a form as the Society shall from time to time direct; and every communication ordered to be published in the Transactions shall be immediately sent to the printer, and fifty copies thereof be given to the author as soon as printed.

5. The order in which papers are read shall determine their places in the Transactions, unless otherwise ordered by the Society; priority of date giving priority of location.

6. The expenses of publishing the Transactions shall be defrayed by subscriptions and sales, aided by such funds as the Society shall from time to time appropriate for that purpose.

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CONTENTS.

PAGE

Extract from the Laws of the Society relating to the Transactions, ... ii
Officers of the Society for the year 1869, ... v
List of the members of the Society elected since the publication of the Twelfth volume, . . vi
List of the members reported deceased since the publication of the Twelfth volume, . . viii

PART I.

ARTICLE I.

On California Mosses. By Leo Lesquereux, ... 1

ARTICLE II.

On the Mathematical Probability of Accidental Linguistic Resemblances. By Pliny Earle Chase, A.M., ... 25

ARTICLE III.

On the Comparative Etymology of the Yoruba Language. By Pliny Earle Chase, A.M., . 35

ARTICLE IV.

Thoughts on the Influence of Ether on the Solar System. By Alexander Wilcocks, M.D. (with a plate), ... 73

ARTICLE V.

On New Mosses. By Thomas P. James, ... 105

ARTICLE VI.

On the Numerical Relations of Gravity and Magnetism. By Pliny Earle Chase, A.M., . . 117

PART II.

ARTICLE VII.

On the Myriopoda of North America. By H. C. Wood, Jr., M.D. (with three plates, I, II, III), 137

PART III.

ARTICLE VIII.

On the Hydrology of the Basin of the River Saint Lawrence. By Thomas Evans Blackwell, M. I. C. E. (with two plates, IV, V), ... 249

ARTICLE IX.

Notes on a Map intended to Illustrate Five Types of Earth-surface in the United States, between Cincinnati and the Atlantic. By J. P. Lesley (with a map, VI), ... 307

ARTICLE X.

On Fucoides in the Coal Formations. By Leo Lesquereux (with a plate, VII), ... 313

ARTICLE XI.

Notes upon the Geology of some portions of Minnesota, from St. Paul to the Western Part of the State. By James Hall, ... 329

ARTICLE XII.

A Contribution to the Knowledge of the Flora of the Coal Period in the United States. By Horatio C. Wood, Jr., M.D. (with two plates, VIII, IX), ... 341

ARTICLE XIII.

Synopsis of the Cyprinidæ of Pennsylvania. By Prof. Edward D. Cope (with four plates, X, XI, XII, XIII), ... 351

Supplement on some New Species of American and African Fishes, ... 400

ARTICLE XIV.

On Species of Forest Plants from the Tertiary of the State of Mississippi. By Leo Lesquereux (with ten plates, XIV, XV, XVI, XVII, XVIII, XIX, XX, XXI, XXII, XXIII), . . . 411

ARTICLE XV.

On the Phalangia and Pedipalpi collected by Professor Orton in Western South America, with the Description of New African Species. By H. C. Wood, Jr., M.D. (with a plate, XXIV), 435

ARTICLE XVI.

Remarks on Thirteen New Species of Crinoidea from the Palæozoic Rocks of Indiana, Kentucky, and Ohio, and a Description of certain Peculiarities in the Structure of the Columns of Dolatocrinus, and their Attachment to the Body of the Animal. By Sidney S. Lyon (with two plates, XXV, XXVI), ... 443

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TRANSACTIONS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY.

ARTICLE I.

ON CALIFORNIAN MOSSES.

BY LEO LESQUEREUX.

Read June 19th, 1863.

The history of the Mosses or the Bryologia* of the western shores of the North American continent, presents a peculiar anomaly: that of having been noticed by one of the earliest celebrated botanists of England, and of being, even at this time, scarcely known to the scientific world. Menzies collected specimens of mosses in California and Southern Oregon during his travelling explorations from 1787 to 1793. Some of the species were published by himself in the *Transactions of the Linnean Society;* others by Hooker in his *Muscologia Exotica*, and a few by Schwægrichen. The number of these species was quite small. In Müller's *Synopsis Muscorum*, which appeared in 1851, there are only fifteen species published and described from the western shores of North America.

The first important contribution to the Bryologia of California was made by Dr. Bigelow, botanist of a United States exploration from the Mississippi to the Pacific Ocean

* I use this word in its general sense as representing the history of the mosses, either in their specific relation or in their local and geographical distribution.

under Lieutenant A. W. Whipple. The mosses there gathered by this excellent botanist were enumerated and described by Mr. W. S. Sullivant for the report of the explorations in 1856. Somewhat later, in 1859, a gentleman from Germany, Mr. T. Bauer collected mosses in a tour from San Francisco to the Sierra Nevada, and sent them to Hampe, who published a description of eleven species in a pamphlet prepared in 1860 for the Bot. Zeitung. Recently, a young botanist, Mr. Hy. Bolander, formerly of Columbus, Ohio, having taken up his residence at San Francisco, has given particular attention to the study of the Californian mosses, and in less than one year, has collected as many species as all the other collectors together. Mr. Bolander's contribution is rendered particularly interesting to bryological science, not only by the number of species, but by the great care manifested in collecting and preserving fine specimens in a perfect state of maturity, and in such abundance as to render examinations satisfactory, and also noting the time of maturity, the habitat, and all circumstances necessary to arrive at a correct knowledge of the species in all its phases.

He sent me by mail, almost weekly, examples of species new to science or new for California. Hampe's remarks about the Bryologia of the Sierra Nevada,—*that this country is still for mosses terra incognita*, is apparently applicable to the whole State of California. Nevertheless, the following enumeration of Mr. Bolander's mosses will show, as was already done by that of Dr. Bigelow's collection, that the conclusions of the celebrated German botanist cannot be taken in such a general way as he appears to have done, and that the species are by far not all new.

SPECIES OF MOSSES COLLECTED BY MR. HY. BOLANDER IN CALIFORNIA (1862 TO 1863).

1. EPHEMERUM serratum *Hmp.*

In a meadow near Mission-Dolores. March.

2. ACAULON muticum *C. Mull.*

Same place. March.

3. PHASCUM cuspidatum *Schreb.*

Same place. Var: ♂ piliferum humile *Bryol. Eur.* On the ground near Oakland, San Francisco. March.

4. PLEURIDIUM subulatum *Bryol. Eur.*

The calyptra has a longer point than the European form, which is the only difference. Wet ditches and dry hills, San Francisco. April.

5. WEISIA viridula *Brid.*

A very variable species. One of the Californian forms has the capsule somewhat longer

and more slender, pale green, marked, even before full maturity, with eight regular deep striæ. The teeth are simple, shorter, irregular, variable in size. On the ground, San Francisco.

6. Weisia cirrhata *Hedw.*

Appears abundant in California, and variable. A fine form sent with the normal one, is more compactly cæspitose, with shorter leaves, longer teeth of the peristome often split at the summit and marked with stronger articulations. Grows on the stumps of *Sequoia viridis*, Redwood, &c., around San Francisco.

7. Dicranum varium *Brid.*

On perpendicular sandstone rocks, constantly watered by a spring near the Bay of San Francisco. The watering has elongated the stems, rendering them more slender, and giving to this form a peculiar look, different from its common appearance. Nevertheless, anatomical examination does not show any modification of specific characters.

8. Ceratodon purpureus *Brid.*

The common form and also a variety with white pedicels (var. xanthopus *Sul. & Lesq.* in Musci exsic. Amer. 1st edit.) On roots and stumps of *Sequoia viridis*, &c.

9. Fissidens limbatus *Sul.* Bot. of the Ex.

Wet, shady ground near San Francisco. May. Appears common.

10. Trichostomum tophaceum *Brid.*

Wet rocks, Fort Point. This species shows on its peristome all the varieties indicated in the Bryologia Europea. Even a smaller form with shorter capsules and a dark green color of foliage, has the peristomal teeth generally short, obtuse, united in one in their whole length, presenting thus a peristome of sixteen short, somewhat irregular divisions, like that of some *Seligeriæ*. But even on the same specimens, this variety disappears, and some capsules have the divided teeth of a true Trichostomum.

11. Trichostomum flexipes *Bryol. Eur.*

Trichostomum crassinerve Hampe, in pamphlet, 1860. Mr. Hampe has made of this a new species, separated by the smaller size of the plants, narrower leaves, thicker evanescent nerves, smaller areolation, and white peristomal teeth. Comparing Bolander's and Hampe's specimens with original specimens from Sardinia, I find them perfectly identical. The areolation is the same, the color of the peristome, as well as the size of the plant and of the leaves are variable. This year, Mr. Bolander sent from Marin County specimens twice as large as the European ones, all the leaves having an evanescent nerve. In this large variety, the pedicel of the capsule is perfectly straight, as it is often also in the common form. Grows on shady ground near Oakland, &c.; appears common in California.

12. Barbula vinealis *Brid.*

Very common and variable around San Francisco; on rocks, boulders, and wet ditches near the bay. May. Var. *α* has the ramification, form of leaves, &c., of Barbula vinealis; but the operculum and peristome of Barbula flexifolia *Hmp.* Var. *β* flaccida *Bryol. Eur.* has the capsule and operculum of Barbula vinealis, and the long-linear, lanceolate, canaliculate, open-reflexed, loosely-imbricated leaves of Barbula flexifolia. This variety is apparently the equivalent of Barbula elata *C. Müll.* Same habitat as the normal form.

13. Barbula flexifolia *Hampe loc. cit.*

The characters separating this species from Barbula vinealis are, 1st. The leaves crisped when dry, squarrose-reflexed when humected, with revolute margins. 2d. The somewhat narrower, dark red capsule, with a longer operculum. 3d. The longer and more twisted teeth of the peristome, and their red color. These last characters are unreliable, the teeth varying in color, and being more or less twisted even on the same specimens, according to the age of the capsule. The characters taken from the leaves are also unreliable, and as this moss covers the sand along the shores, and in the vicinity of boulders covered with Barbula vinealis, these differences, I think, may be ascribed to variations from change of habitat.

14. Barbula virescens *Sp. nov.* Inflorescentia, ramificatione priori proxima, differt: Caule longiori, inferne bruneo, superne amœne pallide virescente; foliis longioribus e basi lanceolatis, margine usque ad apicem revolutis, undulatis, areolatione duplo laxiori, distincta, areolis ovalibus; perichætialibus apertis; operculo breviori, annulo latiori.

This species is intermediate between Barbula flexifolia *Hmp.* and Barbula semitorta *Sul.*, two species already closely related. From the first it differs essentially by the areolation; from the second, by the revolute margin of the longer leaves, a longer and more twisted peristome, and a broader basilar membrane. On rocks, Redwood and Oakland, near San Francisco.

15. Barbula artocarpa *Spec. nov.* Dioica, compacte cæspitosa. Caule gracili, brevi, subsimplici. Foliis inferioribus brevibus, e basi ovata lanceolatis, nervo valido percurrente brevi-subulatis; superioribus longioribus, longius lanceolatos ubulatis; Perichætialibus latioribus, basi amplectentibus superne coarctatis subulatis erectis; Areolatione foliorum compacta illæ Barbulæ vinealis simili; Capsula ovata cylindrica brevi gracili, ore coarctata, operculo longe rostrato subcurvato; Annulo simplici persistente lato; Peristomii dentibus gracilioribus, albidis, semel tortis.

Except for its pretty large annulus, this species would agree with Barbula gracilis *Schw.* which it exactly resembles by the ramification, the form of the leaves and of the capsule. It is also nearly related to Barbula subfallax *C. Müll*, which has also no annulus, and a shorter basilar membrane. Mount del Diablo, California.

It is, indeed, with some misgiving, that I add two new species to this group of Barbulae already too much divided. But I have no other alternative but to do it, or to recall as mere varieties a number of forms considered as species by other authors, and whose characters are of the same kind and no more definite.

16. Barbula convoluta *Hedw.*

On rocks near San Francisco. May.

17. Barbula Wahliana *Schultz.*

Clay soil, San Francisco.

18. Barbula Bolanderi *Spec. nov.* Gregaria, dioica. Caule brevi simplici, vel fasciculatim comante-ramoso; Foliis inferioribus brevibus apertis, superioribus dense in rossulam imbricatis reflexis lingulatis vel oblongis obtusis vel nervo crasso fusco percurrente brevi-apiculatis, margine medio reflexis, raro revolutis, quandoque planis; areolatione basilari quadrato-elongata laxa pellucida superne densa chlorophyllosa quadrata-polygona papillosa. Perichætialibus internis brevioribus. Capsula in pedicello brevi rubello crasso, cylindrica erecta vel subcernua atro-sanguinea; operculo rostrato obtusiusculo. Peristomii dentibus gracilioribus tortilibus rubellis granulosis; membrana basilari angusta tessellato luteo-albida; annulo brevi simplici persistente. Planta mascula graciliori, femineis intermixta. Perigonialibus brevibus, e basi late ovata superne lanceolatis obtusis, antheridiis paucis paraphysibus que duplo longioribus apice inflatis.

A fine species allied to Barbula marginata *Bryol. Eur.* Rocks near the Bay of San Francisco. Abundant.

19. Barbula amplexa *Spec. nov.* Gregaria, dioica, priori valde affinis. Caule simplici brevi; foliis laxe imbricatis apertis lingulatis longioribus mollibus obtusis nervo valido sub apice evanido instructis; areolatione basi laxa quadrato-elongata, superiori densiori polygona pellucida echlorophyllosa; Perichætialibus internis binis elongatis, vaginulam arcte amplectentibus, erectis apice tantum subito reflexis; Capsula in pedicello rubello brevi, cylindrica erecta breviori, colore pallide-viridi; operculo recto obtuso pallide rubello. Peristomio, annulo flore que masculo priori similibus.

This species is distinct from the former, especially by its soft leaves with empty areolation; by the long internal perichætial leaves, erect and embracing the vaginula and the base of the pedicel, and only reflexed at the summit; by the shorter, smaller capsule and shorter lid of a different color. Near San Francisco. May.

20. Barbula muralis *Hedw.*

A few specimens of this species were sent, mixed with Barbula flexifolia *Hmp.* labelled: On rocks near San Francisco.

21. Barbula laevipila *Schw.*

The Californian species appears a reduced form of the European. It has shorter stems, shorter leaves, and a slender capsule. On clay soil in Mount Diabolo. May.

22. Barbula ruralis *Hedw.*

On rocks near Mission Dolores, Oakland, &c. Very common in California. May.

23. Barbula Mülleri *Bryol. Eur.*

On rocks; less frequent than the former, and found in the mountains. Mount Diablo. May.

24. Barbula latifolia *Bryol. Eur.*

On a fence-post near a creek three miles from San Rafael, Marin County. April, 1863.

25. Desmatodon flavicans *Br. & Schmp.*

On clay soil, San Francisco. Rare.

26. Desmatodon nervosus *Br. & Schmp.*

On the walls of an old Indian abode, and on clay soil; rare. It differs from the European form by the leaves being lingulate, a little more obtuse and shorter apiculate, and by the inflation of the strong nerve above the middle. This last character is not persistent.

27. Anacalypta Starkeana *Bryol. Eur.* var. β brachyodus. *Weisia affinis Hook & Tayl.*

Clay soil, San Francisco.

28. Tetraphis pellucida *Hedw.*

Rotten wood.

29. Encalypta vulgaris *L.*

Monte del Diablo, on clay soil, fissure of rocks.

30. Zygodon Californicum *C. Müll.* Mr. Müller has not seen the male plant of this species. Inflorescentia dioica; planta mascula in iisdem cæspitibus intermixta, femineis validiori sub floribus innovante ramosa; floribus masculinis pentaphyllis; perigonialibus externis duobus e basi dilatata longe linearibus internis brevibus concavis ovato-lanceolatis acutis, versus apicem dentatis nervo ultra medium evanido; antheridiis numerosis paraphysibus que brevibus paucis.

Grows on shaded rocks in a creek, near the road to a paper mill, Marin County. April, 1863.

31. Orthotrichum Texanum *Sul.*

The teeth of the peristome of this species are often separated by sixteen rudimentary fugacious cilioli. The inflorescence is monoecious and the male flowers axillary. On shaded stones near Oakland, San Francisco.

32. Orthotrichum cylindrocarpum *Spec. nov.* Orthotricho strangulato affine, differt; capsula longi-

colla longiori cylindrica graciliori emersa; operculo conico longiori; calyptra longiori fusco-lutea, capsulam fere totam tegente, valde pilosa; vaginula pilis longis dense obtecta; dentibus peristomii externi pallidis, ciliolis robustis *longioribus* albidis *articulatis;* flore masculo terminali.

The male flowers are generally at the top of a branch above the innovations, and not merely axillar. The dry, empty capsule is not contracted below the mouth. The ramification, leaves, and areolation are the same. Oakland, on trees, scarce.

33. Orthotrichum Lyellii *Hook.* var. foliis longioribus siccitate magis crispatis *Brid.*

The species is extremely variable, especially for the size of the leaves, sometimes covered with long papillæ, sometimes nearly smooth. It grows on granite rocks and on trees. The form growing on boulders has the leaves generally shorter, sometimes turned to one side, especially at the top of the branches. This form is apparently Orthotrichum papillosum *Hampe.* Our species has only rarely the confervoid filaments which cover the European form. It is common in California.

34. Orthotrichum rivulare *Turn.*

On a fence-post near a creek, Marin County, together with Barbula latifolia *Bryol. Eur.*

35. Schistidium confertum *Bryol. Eur.* var. foliis brevi-piliferis, areolatione densiori, dentibus peristomii rubelli ultra medium superne valde irregulariter lacerato dentatis.

I have not seen the calyptra. This may be a distinct species. On metamorphic rocks, Mount Diablo. May.

36. Grimmia Californica *Sul.*

On granite boulders, Mission Dolores, &c. Common. April.

37. Grimmia trichophylla *Grev.*

On sandstone near Oakland. Among other varieties of this species, there is one with a dark green color, leaves with a shorter hairy point, or even obtuse without pellucid point, areolation more distinctly square at the base, and more compact-obscure above, which might be separated in a species. But these variations are apparently due to the habitat, and this variable species has been already too much divided. It grows on granite boulders near Presidio.

38. Grimmia montana *Bryol. Eur.*

It differs in nothing from the European form but by the dark green color of the plants. Monte del Diablo. April.

39. Grimmia leucophaea *Grev.*

A variety with the hair-point of the leaves more strongly dentate, and the teeth of the peristome more irregularly divided. On granite boulders; common.

40. Racomitrium canescens *Brid.*

It is also a variety differing from the European form by a narrower areolation nearly continuous near the base of the leaves and not papillous; by the hairy pellucid point of the leaves, dentate only, but not rugulose; by the cylindrical-ovate capsule of a lighter color. The plants are generally stronger, and the leaves longer. This variety, by its areolation, bears to the normal form the same relation as this bears to the variety ericoides with more papillous and rugose leaves. On shaded rocks at the banks of a creek, Marin County. April.

41. Hedwigia ciliata *Ehrh.*

On stumps of Sequoia viridis, California. I have never seen this species growing on wood. There may have been a change of labels. This new habitat is remarkable indeed.

42. Braunia Californica *Spec. nov.* Monoica, laxe cæspitosa, fusco-lutea. Caule primario subrepente valde diverse ramoso; ramis erectis gracilibus julaceis apice incrassatis duris, vel simplicibus vel irregulariter innovante ramosis, ramulis brevibus rarius flagelliferis; foliis in sicco appressis, humiditate apertis, ramorum apice subsecundis, e basi subdecurrente oblongo ovatis, apice brevi lanceolatis, pellucide acuminatis vel acumine longiori flexuoso lævi peliferis enerviis, margine versus basim superne que reflexis, medio revolutis; areolatione basilari elongata, alari quadrata, superiori ovato-polygona pulcherrime seriatim catenulata distincta, utraque pagina præcipue externa papillosa; Perichætialibus brevioribus lanceolatis-acutis raro pellucide brevi acuminatis; capsula in pedicello semipolicari pallide luteo sinistrorsum torto, turbinata ore dilatata nuda; operculo conico-elongato obtuso recto.

By the general appearance and color of the stems, this species resembles the slender form of Hedwigia ciliata, the leaves being always terminated by a diaphanous, sometimes very long hairy point. The straight hard branches are variable in thickness, generally inflated at the innovations, and below the short flowers bearing branches. The male flowers, like the female, are at the top of one of these branches. Their many-leaved floral envelope has oval, short, pointed leaves, the point also diaphanous. As in the other species of this genus, the vaginula is very long, descending to the base of the fruit-bearing branch. The capsule, of a light brown color, is, when deoperculated, exactly top-shaped, broad-mouthed. The dark yellow calyptra split on one side is long, and incloses the whole capsule till its maturity. Grows in large patches on metamorphized rocks in Mount Diablo, up to 3000 feet. April, 1863.

43. Atrichum undulatum *Beauv.*

Santa Cruz Mountain, 4000 feet. Prof. Brewer, legit.

44. Polytrichum juniperinum *Hedw.*

Rocks, Mission Dolores, &c.

45. Aulacomnium androgynum *Schw.*

On my Californian specimens, the male flowers are disciform as Bridel indicates it, and not gemmiform as is generally the case in the European specimens. The brown antheridiæ and filiform paraphyses are very numerous. On old logs of Sequoia viridis; appears to be common in California. April.

46. Bryum Tozzeri *Grev.*

Deep shaded ditches near San Francisco.

47. Bryum Wahlenbergii *Schw.*

Wet rocks, San Francisco. May.

48. Bryum Billarderii *Schw.*

Deep Cañon, Mount Diablo. May.

49. Bryum Californicum *Sul.*

In its full development, the cilioli of the internal peristome are long, mostly two together, and appendiculate. Common in the hills of Oakland on ground, in meadows near shrubs. April.

50. Bryum occidentale *Sul.*

Like its near relative *Bryum cæspiticium*, this species is very variable. The ramification is from below and around the first fruit-bearing bud. The branches more or less numerous, nearly naked below, are either short, bearing at the top a thick bud of closely imbricated, short ovate, pointed, concave leaves; or, on sandy wet soil, become elongated, flagelliform, bearing distant, lanceolate, narrow, pointed leaves. The color of the capsule is as variable as its size. It is more generally blood red, but in the shade, it is either buff colored, or even greenish or variegated, half red, half brown. On sandy soil and rocks near the Bay of San Francisco.

51. Mnium insigne *Mitt.*

In woods, Oakland. Sterile.

52. Mnium Menziesii *C. Müll.*

Shaded banks of a creek, Marin County. April, 1863.

53. Bartramia stricta *Brid.*

Differs only from the normal form by the pedicel *round-oval* at the top, and not square. On rather wet rocks, Mission Dolores.

54. Bartramia Menziesii *Turn.*

Glyphocarpa Baueri *Hampe* in pamphlet, 1860. Dioica, laxe, late, cæspitosa; Caule elongato, bi-tri-pollicari et ultra, simplici vel parce innovante ramoso, e basi folioso, usque ultra medium tomentoso radiculoso brunneo, superne amœne viridi; Foliis undique appressis vel subapertis, humiditate erecto-apertis, e basi cava plicata margine reflexa ovato-lanceolata, superne lanceolato subulatis, margine dentatis, dorso nervoque valido in subulam exeunte scabris; Perichætialibus longioribus vix latioribus conformibus; Areolatione foliorum basi quadrato-minori distincta, superne longiori obscura papillosa; Theca in pedicello innovando laterali semipollicari pallide rubello vel stramineo sinistrorsum torto, ovali erecta regulari lævi pallide rufescente vel viridi; ore nuda, membrana simplici tantum circumdata; vel membrana irregulariter laciniata sub vel semi-peristomata; vel dentibus 16 lanceolatis, irregulariter articulatis fusco-rubellis haud vel cum linea mediali notatis simpliciter sed perfecte peristomata; Planta mascula sic et fœminea innovando-laterali vel terminali gemmacea; Foliis perigonialibus basi ovatis subito longe subulatis scabris; antheridiis elongatis curvatis fusco luteis paraphysibusque numerosis.

This species is evidently the one described by Turner, and collected by Menzies in California in 1792, as shown by original specimens preserved in Taylor's herbarium, and kindly furnished to me for comparison by Mr. Wm. S. Sullivant. The above-described modifications of the peristome would at first lead to the belief that there are two different species, the one without, the other with a simple peristome. But on the same specimen, I have found some capsules with a simple peristome of sixteen irregular, brown-reddish teeth; others with the pellucid peristomatal membrane, either simple and entire, or broken in short laciniæ without definite shape, and more or less united together, or with the same membrane divided into sixteen laciniæ already taking the shape of irregular teeth, but still preserving the pellucid tissue of the membrane. It is therefore evident that some peculiar influence, causing a more or less perfect development of the plant, is the only reason of the difference. The oval form of the capsules is more or less elongated, sometimes nearly round; except this all the characters are perfectly alike. This remarkable variation in the peristome exemplifies the value of Schimper's assertion in the Bryologia Europea; that little reliance can be put on the peristome of the Bartramiæ to found generic divisions. We have here both the genera Glyphocarpus *Brid.* and Bartramia *Auct.* united in the same species.

According to Mr. Bolander, this Bartramia is very common in California, growing on rocks, Mission Dolores, Marin County, Mount Diablo, &c.

55. Funaria Muhlenbergii *Schw.*

Deep Cañon, Mount Diablo.

56. Enthostodon Bolanderi *Sp. nov.* *Enthostodonte Templetoni* simile differt: foliis longius acuminatis, laxius areolatis, nervo vix medio ascendente; Capsulæ collo longiori, basi subinflato, capsulaque propria breviori ovato-turbinata; operculo longiori, umbonato vel convexo obtuso apiculato; peristomii dentibus integris articulatis (nec nodosis); Foliis perigonialibus enervibus. *Enthostodonti commutato Müll.* quoque proximum

differt: foliis versus apicem subdentatis (nec integerrimis) peristomiique dentibus tantum articulatis (nec nodosis, nec linea media exaratis).

Wet rocks near the Bay of San Francisco. April.

57. PHYSCOMITRIUM pyriforme *Brid.*

On swampy ground, Marin County. April. Scarcely ripe.

58. FONTINALIS Californica *Sul.* Bot. of the Ex.

In a willow swamp near San Rafael. April.

59. ANTITRICHIA Californica *Sul. MSS.* Antitrichiæ curti pendulæ proxima differt: ramis brevioribus julaceis filiformibus ve; foliis in sicco arcte compressis, brevius acuminatis vix dentatis, areolatione densiori; capsula cylindrica longiore rubella; pedicello breviore recto; peristomii dentibus laxius et obscure articulatis; sporis duplo minoribus; perichætialiis longius lanceolato-acuminatis dentatis; vaginula crassiore.

On oak trees near San Francisco. Mr. Sullivant, in Botany of Whipple's Expedition, considered this species as different; but the specimens of the Expedition were without fruit, and thus it could not be exactly determined.

60. FABRONIA pusilla *Raddi.*

On oak trees, San Francisco.

61. PTEROGONIUM gracile *Hedw.*
Leptohymenium duplicato-serratum Hmp.

Mr. Hampe has made a new species of our Californian moss; but after a close examination of a large number of specimens, I do not find any difference between the European species and ours, except perhaps a little larger annulus for this last. The character taken from the size of the plant is unreliable; some Californian specimens being larger than any of those which I have from Europe, and the serrature of the leaves appears just the same in both forms. On rocks near the Bay of San Francisco. Common.

62. ALSIA circinata *Sul. Icones Musc.* tab. 72[b] ined.
Leptodon circinatus Sul. in Whipple's Expedition.

Dr. Bigelow's collection had only male plants of this species, which by leaves and ramification is closely allied to the genus *Leptodon*. Mr. Bolander has collected it with ripe capsules, and the peristome shows the species to be a true *Alsia*. On oak trees near San Francisco.

63. ALSIA Californica *Sul.*

On trees, rocks, &c. Common.

64. HYPNUM crispifolium *Hook. Musc. exot.*
Hypnum (Thuidium) ramulosum Hampe in litt. C. Müll.

Though Hooker's figure and description of this species are not satisfactory, the essential

characters of his species agree well with Müller's description, and also with our specimens. It is remarkable enough by its granular areolation (areolis reticuli minutissimis Hook.), its whitish or nearly pellucid nerve (nervo pallido sæpe sub pellucido Hook.), the long dentate flexuous acumen of the leaves (folia ramea omnia longe acuminata quandoque pilo flexuoso terminata Hook.), its short, rough, red pedicel (seta uncialis rubra tuberculosa Hook.) &c. Mr. Hooker even mentions the split teeth of the internal peristome resembling that of a Bartramia, and the general resemblance of the moss in some points with Hypnum abietinum. Müller's description of Hypnum ramulosum agrees perfectly and in every point with our specimens. On shaded rocks near the Paper Mill, Marin County.

65. Hypnum (Rhyncostegium) rusciforme *Weis.*

Spring in a cañon near San Francisco.

66. Hypnum (Thamnium) Bigelowii *Sul.*

On the bark of trees and on the ground. Very variable in size.

67. Hypnum (Eurynchium) Stockesii *Bryol. Eur.*

On the ground in the shade. Common.

68. Hypnum (Eurynchium) Whippleanum *Sul.* Bot. of the Ex.

Specimens of this species found mixed with Fissidens limbatus in Mr. Bolander's collection, show that the pedicel is sometimes smooth. On shady ground near San Francisco.

69. Hypnum (Eurynchium) Oreganum *Sul.*

On shaded old logs in a creek, Marin County.

70. Hypnum (Isothecium) Brewerianum *Spec. nov.* Hypno myosuroidi peraffine differt: colore sordide-luteo viridi, cæspitibus densioribus, ramis crassioribus, subjulaceis, raro elongatis filiformibus; foliis arcte imbricatis appressis, versus basim latioribus, superne subito in acumine brevi contractis, valde concavis vix denticulatis. Perichætialibus longius lanceolato subulatis reflexis; capsula cylindrica breviore rufa.

This species could be considered as Hypnum stoloniferum *Hook.*, but that this last species has, according to Hooker, drooping capsules and plants of a larger size. Hooker's plant was collected by Menzies on the roots of trees, even pending from branches. Ours, according to Mr. Bolander's remarks, grows on granite rocks near Mission Dolores. It was also collected by Professor Brewer of the Californian State Geological Survey, and is dedicated to him.

71. Hypnum (Brachythecium) Bolanderi *Spec. nov.* Dioicum laxe lateque cæspitosum pallide amœne viride. Caule diverse ramoso, ramis elongatis flexuosis, vel suberectis rigidis sub pinnatim vage ramosis; Foliis undique imbricatis apertis, ovato-lanceolatis breviter acuminatis margine plano undique serrulatis, nervo ultra

medio instructis; areolatione laxiori, cellulis angustis pellucidis, alaribus parum numerosis distinctis ovato-quadratis pellucidis; Perichætialibus e basi lata vaginantibus pellucide laxe elongate reticulatis subito fere in acumine flexuoso vel subreflexo attenuatis obsolete nervosis; Theca in pedunculo brevi semipollicari rugoso sanguineo, gibboso-ovali; annulo lato composito revolubili, operculo conico-acuto brevi; peristomii interni dentibus hyantibus, ciliis binis gracillimis separatis.

Ab Hypno Sullivantii *Spruce*, proximo differt: areolatione foliorum laxiore; cellulis alaribus majoribus quadratis distinctis: foliis margine planis; annulo latiori revolubili; operculo conico brevi, &c.

On the ground in the shade of Oreodaphne Californica. April.

72. Hypnum (Scleropodium) illecebrum *Bryol. Eur.*

On rocks and on the ground, San Francisco, Oakland.

73. Hypnum (Scleropodium) caespitosum *Bryol. Eur.*

On the ground among shrubs, &c., near San Francisco.

74. Hypnum (Scleropodium) Californicum *Spec. nov.* Dioicum, laxe intricato-cæspitosum. Caule serpente vage ramoso; ramis longioribus filiformibus radicantibus; foliis laxe imbricatis apertis, ovato-lanceolatis acuminatis concavis integris vel vix serrulatis, nervo valido sub acumine evanido instructis; areolatione angustata elongata, cellulis alaribus numerosis, ovato-quadratis distinctis plus minusve granulosis; Perichætialibus late ovato-amplectentibus superne lanceolatis longe piliformi acuminatis, internis erectis, externis acumine reflexis; capsula in pedicello elongato gracili torto superne tantum papilloso rubello, inferne stramineo lævi, ovata-cylindrica brevi, pallide viridi cernua sub ore subconstricta, vacua erecta equali; late composite annulata; Operculo pallido conico acutiusculo lato; Peristomii externi dentibus sanguineis, interni ciliis luteis pertusis, ciliolis singulis vel binis robustis articulatis separatis. Floræ masculæ antheridiis robustis numerosis paraphysatis; foliis perigonialibus late-ovatis brevi-acuminatis integris.

On rocks and dry sand near the Bay of San Francisco.

75. Hypnum (Camptothecium) arenarium *Spec. nov.* Dioicum, laxe lateque cæspitosum. Caule intricato suberecto parce vageque ramoso; ramis secundariis vel brevibus erectis subcurvatis utrinque attenuatis, vel longioribus filiformibus radicantibus. Foliis confertis undique imbricatis erectis subappressis, lanceolatis acuminatis striatis, margine reflexo subserrulatis, plicaturæ marginalis basi utrinque cavis, nervo valido sub acumine evanido instructis, dense anguste areolatis, cellulis alaribus numerosis basim integram folii efficientibus, ovato-rotundatis minimis vix distinctis; Perichætii elongati foliis externis brevioribus late-ovato acuminatis reflexis, superioribus amplectentibus subito in acumine piliformi erecto vel reflexo serrulato terminatis, margine superne eroso parce grosse dentatis, areolatione laxa basi quadrata polygona superne elongata pellucida; Foliis perigonialibus brevibus late-ovatis brevi acuminatis vel acutis integris nervosis, areolatione pellucida; Capsula in pedicello elongato gracili basi papilloso rugoso superne sublævi, parva ovato-cylindrica cernua; Operculo magno conico obtuso apiculato; Processus interni ciliis pertusis, ciliolis binis vel singulis brevibus fugacissimis separatis; Annulo composito lato persistente.

Ab *Hypno lutescente Hedw.* cui proximum, primo intuitu forma graciliori, capsula cernua brevi, &c., differt.

Covering sand around bushes near San Francisco.

76. Hypnum Nuttallii *Wills. Bryol. Brit.*
Leskea Californica Hampe. Pamphlet, 1860.

This fine species is a true Camptothecium related to Camptothecium aureum

Lag., and easily distinguished from any other species. On the bark of oak trees, common in California.

77. Hypnum (Amblystegium) serpens *L.*

In a swamp at the foot of the Oakland Redwood Hills. March.

78. Hypnum subimponens *Spec. nov.* *Hypno imponente* primo intuitu similimum differt: Foliis caulinis integris vel raro summo acumine subserrulatis; cellulis alaribus vel nullis vel perpaucis minoribus; areolatione densiori; foliis perichætialibus brevi-acuminatis erectis appressis integris; capsula graciliori cernua; operculo conico-obtuso; peristomii interni ciliis singulis vel binis longis gracilimis; annulo composito lato revolubili; vaginula nuda.

Shaded rocks in a creek, Marin County.

79. Hypnum riparium *S.*

In a willow swamp, Marin County, &c.

Though we do not know probably one-half of the species of mosses inhabiting California, the materials on hand are already sufficient to permit us an inquiring look into the general character and the geographical distribution of the Bryologia of that country.

Mr. W. S. Sullivant's examination of the mosses collected in California by Dr. Bigelow, has enumerated sixty-four species, thirty of which have not yet been found by Mr. Bolander. Menzies, Hooker, Hampe, Müller, and other authors have mentioned eighteen species from the west coast of North America, twelve of which are also not in Mr. Bolander's collection. This gives us an amount of one hundred and twenty-one species of mosses now known in California. Of these, forty-two appear peculiar to Western North America, some of them ascending higher north in Oregon, but their northern range is still undetermined. Forty-two species are common to California, Eastern North America, and Europe; thirty-four are found in California and Europe, but not in Eastern North America, and none are common to California and Eastern North America solely. Three species have a range going somewhat out of this division, *Orthotrichum Texanum* and *Hypnum Nuttallii* appear to be species of a warmer climate; the first being found in Mexico, the second in Western Texas. *Trichostomum corniculatum Schw.* goes as high north as Kamtschatka.

The species common to California, Europe, and Eastern North America, are mostly wandering or universal species, found nearly over the whole world in a temperate zone: some *Phascaceæ*, *Gymnostomum curvirostrum*, *Weisia viridula*, *Dicranum virens*, *Ceratodon purpureus*, *Tetraphis pellucida*, *Hedwigia ciliata*, &c., &c. On the contrary, those common only to California and Europe, and wanting in Eastern North America, are typical forms: species of *Trichostomum*, *Barbula*, *Desmatodon*, *Anacalypta*, *Zygodon*, *Braunia*, *Bryum*, *Hypnum*, especially of the section *Scleropodium* and *Camptothecium*. This at once already

shows the relation of the Bryological flora of California with that of Europe, and at the same time its entire disruption from that of Eastern North America. But the relation between the mosses of California and of Europe, is rendered still more remarkable by the identity of the peculiar habitat of some species, and at the same time by the near affinity of species which we consider as true Californian, with typical European forms. Thus on one side, Mr. Bolander finds *Desmatodon nervosus* on the walls of an old Indian abode, and Schimper found it first on the old walls surrounding Strasbourg. *Barbula latifolia* and *Orthotrichum urnigerum*, both species very rare in Europe, grow sometimes together on the stumps of old willow trees, or on old logs near running water, and Mr. Bolander finds them in California both together on an old fence-post in a creek. *Anacalypta Starkeana* and *Trichostomum flexipes* have in California also just the same habitat that both have in Sardinia, Smyrna, and other places on the shores of the Mediterranean Sea: for it is especially with the Mediterranean shores that California is related by its mosses. On another side, and considering the affinity of peculiar Californian species with European types, we find *Barbula vinealis* pertaining to Europe and California, and here six or seven species described as new, but so nearly related to the normal form that they might be considered as varieties only. *Barbula marginata*, a peculiar type found all around the Mediterranean Sea, in Spain, South France, Algeria, &c., is in California, with two peculiar or new species also very nearly related to it. The species of *Grimmia* and of *Bryum* present in California the same subdivision of forms, and the same relation of new species with European types. In the section *Scleropodium* of the genus *Hypnum*, we find in California with the two European species, a third one of a diminutive size but of the same affinity, and in the section *Camptothecium*, California has a species nearly allied to *Hypnum lutescens* of Europe, having precisely the same and peculiar habitat, viz., covering the sand around bushes. Even the fine new *Braunia*, the Californian representative of a genus whose species are very rare, is related more perhaps with *Braunia secunda Müll.* of the barren mountains of Mexico, but nearly also with *Braunia sciuroides Bryol. Eur.*, a very rare plant of the southern valleys of Switzerland.

Is it possible to explain this remarkable analogy between the Bryologia of California and that of Southern Europe, by some law of transmission of species between intermediate points as that which apparently governs the distribution of the phænogamous plants? As the disruption eastward through Eastern North America is complete, we can only, to solve the question, look westward, in Japan and the adjacent islands, and see if we find there some link of connection.

Of the Bryology of Japan, we know nearly as much as of that of California, especially from the researches and collections of Mr. Charles Wright. Now we find, according to

data published formerly,* that of eighty-six species gathered in Japan, thirty-three are proper to that country and described as new; eight are exclusively common to Japan and Eastern North America, six to Japan and Europe, thirty-one to Japan, Europe, and Eastern North America, seven to Japan, Europe, Eastern and Western North America, and two only common to Japan, Europe, and Western North America. From this it is also evident that there is no connection whatever westward between the Bryologia of Europe and that of California; that this last stands thus entirely isolated, and that to explain its relation with the flora of Southern Europe, we have to look for another cause of distribution than that of a transmission of species through intermediate points. This research is worth making, and to render it more interesting and at the same time more conclusive, the best way, I think, is to present in a tabular arrangement the number of species of each genus inhabiting the eastern and the western side of North America, compared with the number of species of the same genera found in Europe.

Counting all the species of mosses now known as belonging to Eastern North America, including Drummond's mosses, and those which have been found as far west as the Rocky Mountains, exclusively of those of Western North America, I find four hundred and ninety-three species. Perhaps a few more not yet recorded, have been found recently by Mr. Thomas P. James, or other American bryologists. Thus the round number five hundred would be reliable enough. Their distribution according to genera is as follows:

* Characters of some new Musci collected by Charles Wright in the North Pacific Exploring Expedition under the command of Captain John Rodgers by William S. Sullivant and Leo Lesquereux (pamp., 1859).

Whole number of species in each genus.		Exclusively E. N. Amer.	Europe and E. N. Amer.	Also in California.	Whole number of species in each genus.		Exclusively E. N. Amer.	Europe and E. N. Amer.	Also in California.
No. 1, 16	Sphagnum, . . .	8	8		No. 21, 1	Conomitrium, . .		1	
2, 3	Andræa, ...		3		22, 13	Fissidens, . . .	8	5	
3, 1	Archidium, . . .	1			23, 9	Trichostomum, . .	2	7	
4, 18	Phascum, . . .	7	11	4	24, 13	Barbula, ...		13	3
5, 5	Bruchia, . . .	5			25, 7	Desmatodon, . .	3	4	1§
6, 1	Hymenostomum,* .		1		26, 1	Anacalypta, . . .		1	
7, 3	Gymnostomum, .		3	2	27, 4	Didymodon, . . .		4	
8, 2	Weisia, ...		2	1	28, 2	Dystichium, . .		2	
9, 2	Rhabdoweisia, . .		2		29, 1	Eustichium, . .		1	
10, 1	Blindia, ...		1		30, 4	Pottia, ...		4	1‖
11, 3	Seligeria, . . .		3		31, 1	Tetraphis, . . .		1	1
12, 1	Arctoa, ...		1		32, 1	Tetrodontium, . .		1	
13, 1	Campylostelium,† .		1		33, 6	Encalypta, . . .		6	1
14, 5	Campylopus,‡ . .	4	1		34, 1	Syrrhopodon, . .	1		
15, 1	Dicranodontium, .		1		35, 3	Zygodon,¶ . . .	1	2	
16, 2	Trematodon, . .	1	1		36, 1	Drummondia, . .	1		
17, 1	Angstrœmia, . .		1		37, 20	Orthotrichum, . .	6	14	2
18, 30	Dicranum, . . .	3	27	1	38, 1	Macromitrium, . .	1		
19, 1	Ceratodon, . . .		1	1	39, 1	Schlotheimia,** .	1		
20, 2	Leucobryum, . .	1	1		40, 2	Ptychomitrium, .	2		

* *Hymenostomum microstomum* ranges from Massachusetts to the base of the Rocky Mountains. It was collected by Drummond, and also by Mr. E. Hall, in a recent tour of botanical exploration with Dr. Parry, 1862.

† The very rare and beautiful *Campylostelium saxicola Bryol. Eur.* was discovered this year by Mr. R. C. Ingraham, of New Bedford, Mass., on boulders of granite.

‡ I could add three apparently new species of this genus, brought from the Rocky Mountains by Mr. E. Hall; but all these species are without fruit, and an exact determination of them is of course impossible.

§ *Desmatodon flavicans* ranges westward from the Rocky Mountains.

‖ *Pottia subsessilis* ranges westward from Illinois. (E. Hall.)

¶ *Zygodon Sullivantii Müll.* It has never been found in fruit, and is thus a species of doubtful affinity.

** The species of this genus, and also of *Macromitrium* and *Syrrhopodon* are tropical. Each of them has still one representative in Eastern North America.

Whole number of species in each genus.		Exclusively E. N. Amer.	Europe and E. N. Amer.	Also in California.	Whole number of species in each genus.		Exclusively E. N. Amer.	Europe and E. N. Amer.	Also in California.
No. 41, 5	Schistidium, . .	2	3	2	No. 62, 4	Physcomitrium,§ .	1	3	1
42, 9	Grimmia, . . .	3	6	3	63, 1	Aphanorhegma, .	1		
43, 1	Coscinodon, . . .	1			64, 14	Splachnum, . . .	1	13	
44, 7	Racomitrium, . .		7	1	65, 10	Fontinalis, . . .	3	7	
45, 1	Hedwigia, . . .		1	1	66, 4	Dichelyma, . . .	2	2	
46, 1	Buxbaumia, . .		1		67, 3	Cryphæa, . . .	3		
47, 1	Diphyscium, . .		1		68, 2	Leucodon, . . .	2		
48, 3	Atrichum, . . .	1	2	1	69, 3	Leptodon, . . .	3		
49, 5	Pogonatum, . . .	3	2		70, 1	Antitrichia, . . .		1	
50, 6	Polytrichum, . .		6	2	71, 7	Anomodon, . . .	3	4	
51, 2	Timmia,* . . .		2		72, 8	Leskea, ...	3	5	
52, 4	Aulacomnium, . .	1	3	1	73, 1	Clasmatodon, . .	1		
53, 30	Bryum, ...	1†	29	4	74, 3	Thelia, ...	3		
54, 11	Mnium, ...	1	10		75, 1	Myurella, . . .	1		
55, 4	Meesia, ...		4		76, 5	Fabronia, . . .	4	1	
56, 1	Amblyodon,‡ . .		1		77, 1	Anacamptodon, .		1	
57, 1	Paludella, . . .		1		78, 3	Pylaisæa, . . .	3		
58, 7	Bartramia, . . .	1	6		79, 1	Homalothecium, .	1		
59, 1	Conostomum, . .		1		80, 1	Platygyrium, . .		1	
60, 4	Funaria, ...	1	3	2	81, 1	Pterigynandrum, .		1	1
61, 1	Enthostodon, . .	1			82, 6	Cylindrothecium, .	5	1	

* *Timmia Austriaca Hedw.* and *Bryum Ludwigii Spr.* are new discoveries for our Bryologia. They were collected in 1862, on the Rocky Mountains near Pike's Peak by Mr. E. Hall.

† *Bryum Lescurii Sul.*, the only Eastern North American species of this genus, is so nearly related to *Bryum carneum L.*, that it might be considered by some bryologists as an American variety of it.

‡ *Amblyodon dealbatus P. B.* In the Rocky Mountains by Drummond. It was found also near Milwaukie (1862), by Mr. I. A. Lapham and myself.

§ *Physcomitrium tetragonum Fürn.* was collected in very fine specimens by Mr. E. Hall in the plains of the Platte River.

Whole number of species in each genus.			Exclusively E. N. Amer.	Europe and E. N. Amer.	Also in California.	Whole number of species in each genus.			Exclusively E. N. Amer.	Europe and E. N. Amer.	Also in California.
No. 83,	3	Neckera, ...		3		No. 87, 106		Hypnum, . . .	34	72	5
84,	3	Omalia, ...	2	1		88,	1	Pilotrichium, . .	1		
85,	1	Hookeria, . . .	1			89,	1	Meteorium,* . .	1		
86,	2	Climacium, . . .	1	1		Total, 493			152	341	42

This table shows the four hundred and ninety-three species of Eastern North America, divided into eighty-nine genera, and distributed thus: one hundred and fifty-two species, or thirty and one-half per cent. belong exclusively to Eastern North America; three hundred and forty-one species or sixty-nine per cent. are common to Eastern North America and Europe, and only forty-two species or eight and one-half per cent. belong to Eastern North America, Europe, and Western North America. But to give a satisfactory view of the distribution of our North American mosses, this table must be completed by a similar one of the Californian species.

Whole number of species in Western North America.			Exclusively W. N. Amer.	Europe and W. N. Amer.	Whole number of species in Western North America.			Exclusively W. N. Amer.	Europe and W. N. Amer.
No. 1,	5	Phascum, ...		5	No. 11,	1	Tetraphis, . . .		1
2,	2	Gymnostomum, . .		2	12,	1	Encalypta, . . .		1
3,	2	Weisia, ...		2	13,	2	Pottia, ...		2
4,	1	Dicranum, . . .		1	14,	1	Zygodon, ...	1	
5,	1	Ceratodon, . . .		1	15,	5	Orthotrichum, . .	2	3
6,	1	Fissidens, ...	1		16,	2	Schistidium, . . .		2
7,	3	Trichostomum, . .	1†	2	17,	5	Grimmia, ...	1	4
8,	22	Barbula, ...	8	14	18,	1	Racomitrium, . .		1
9,	2	Desmatodon, . . .		2	19,	1	Hedwigia, . . .		1
10,	1	Anacalypta, . . .		1	20,	1	Braunia, ...	1	

* These last two genera, like Nos. 34, 38, 39, belong to a tropical flora. Other representatives of these may be found in Florida.

† Belonging to Kamtschatka also.

Whole number of species in Western North America.		Exclusively W.N. Amer.	Europe and W.N. Amer.	Whole number of species in Western North America.		Exclusively W.N.Amer.	Europe and W.N.Amer.
No. 21, 1	Atrichum, . . .		1	No. 30, 1	Physcomitrium, . .		1
22, 3	Polytrichum, . . .	1	2	31, 2	Pterogonium, . .		2
23, 1	Pogonatum, . . .	1		32, 2	Leskea, ...	1	1
24, 1	Aulacomnium, . .		1	33, 2	Alsia, ...	2	
25, 11	Bryum, ...	4	7	34, 1	Neckera, ...	1	
26, 2	Mnium, ...	2		35, 1	Antitrichia, . . .	1	
27, 2	Bartramia, . . .	1	1	36, 1	Fabronia, ...		1
28, 3	Funaria, ...		3	37, 26	Hypnum, ...	15	11
29, 1	Enthostodon, . . .	1		Total, 121		45 (35 per cent.)	76 (62½ per ct.)

Our first remark in looking over these tables, is on the scantiness of the Bryological Flora of California, and the small number of genera in which the species are distributed. *Sphagnum*, *Andræa*, *Campylopus*, *Didymodon*, *Meesia*, *Cryphæa*, *Leucodon*, *Anomodon*, *Thelia*, &c., have, every one of them, a number of representatives in Eastern North America and none in the West. This could be explained perhaps in supposing that we are still too little acquainted with the mosses of California, and that future researches may bring the discovery of a greater number of species. But from what we know of the climate of that State we must admit, I fear, that this scantiness of mosses is rather real than apparent. The vegetation of the mosses, as everybody knows, is particularly favored by a certain degree of constant humidity, and on the contrary, alternate changes of great humidity and dryness tend to destroy it. Now these last climatic conditions are especially marked in California. Professor William H. Brewer, of the Geological Survey of this State, in a very interesting letter on this subject to Mr. W. S. Sullivant, remarks, that the climate of California is particularly unfavorable to the vegetation of the mosses; that except a narrow strip near the coast, where the fog which comes in from the Pacific Ocean brings moisture, the supply of mosses is extremely limited. Everywhere east of the Coast Range, the climate is so very dry in summer, that no dew is deposited on cold nights. Even on mountains of greater altitude, he remarks the same absence of mosses. Professor Brewer ascended Mount Shasta (altitude 14,400 feet), in September, expecting to find there many Alpine mosses, but found none. Of the Coast Range, which, from its exposure to the fogs of the ocean, is apparently better adapted for the vegetation of the mosses, Mr. Bolander

has explored some parts, and he makes the same remarks about the scarcity of mosses. On Mount Diablo he found *Grimmia montana* and *Braunia* on dry rocks, and one or two species only at the bottom of deep cañons.

Now looking to the part of Europe to which the Bryologia of California is essentially related, viz., to the countries around the Mediterranean Sea, and inquiring into their climatic conditions as related to the vegetation of the mosses, we find them remarkably identical.

W. P. Schimper, the greatest of all past and present bryologists, went to Spain some years ago for the purpose of exploring and collecting the mosses of the mountains of that country, especially of the Sierra Nevada. He hoped to find there remarkable and new species, and expected a rich scientific result of his researches. He came back disappointed. The Sierra Nevada of Spain had scarcely any mosses; only those common species found everywhere on dry ground and dry rocks. The high summits of these mountains, covered part of the year by dense fogs, or drenched by diluvial rains, are in the summer entirely dry and barren. Everywhere, says the celebrated professor of Strasbourg, the naked rocks are exposed to view without any trace of those green carpets of *Sphagnum*, *Andræa*, *Gymnostomum*, *Weisia*, *Dicranum*, &c., &c., which cover the constantly-watered declivities of the Swiss Alps, of the Pyrenean, and especially of the Dovrefield Mountains of Norway. The same absence of mosses, due to the same climatic conditions, has been remarked also in the Caucasus by Mr. Dubois de Montperreux, and in Algeria by French botanists. All these countries are about on the latitude of California, and evidently we can trace to a similarity of mere climatic circumstances, the first cause of the extraordinary relation of the bryological vegetation.

The climate of Eastern North America has a greater degree of similarity with that of North and Middle Europe, and we find the same degree of relation in our mosses. We have especially in common the subalpine species, inhabiting the mountains of New York, of Massachusetts, even the summits of the Alleghany Mountains, and the plain near the northern lakes, exactly following the geographical distribution of the Abies. If this flora of ours is not quite as rich as that of Europe, the reasons are easily found, 1st. In the absence of a higher group of Alpine mountains, whose influence tends to enrich the vegetation of mountains of second order. 2d. In the predominance of forests in this country, where they cover the subalpine mountains nearly to their highest summits, preventing therefore the differences caused by a variety of habitat and of station. 3d. In the frequent conflagration of these forests, which tends to destroy in part the vegetation of the mosses, and of course to render it more uniform.

But there is still another cause of distribution of the mosses, by which we can explain, not only the relation of forms, but also the differences which characterize the Bryologia of

the North American continent. It is the adaptation of each species of moss to a peculiar habitat. These humble and apparently useless beings have their geological and lithological preferences far better marked than any other kind of vegetables. They select also to live upon, different species of trees, different substances, the dung of certain animals, the muddy deposits of a peculiar nature, the barren ground or the meadows inhabited by special grasses, old fences, old roofs, old mud walls, &c. This explains, 1st. Why, according to the tables of distribution, the mosses living on the ground, *Gymnostomum*, *Weisia*, *Barbula*, *Desmatodon*, *Trichostomum*, &c., are generally identical in Europe and on both sides of the North American continent, varying only according to climatic influences; and also why, when we come to species living on the bark of trees, or to peculiar substances, the specific and even the generic differences are manifest. Thus we find in Eastern North America, all the species of *Drummondia*, *Ptychomitrium*, *Cryphæa*, *Leucodon*, *Leptodon*, *Clasmatodon*, *Thelia*, *Homalothecium*, *Pylaisæa*, and in Western North America, *Alsia*, exclusively arboreous and exclusively indigenous, most of these genera having not even any specific representative in Europe. In other genera, like *Orthotrichum*, *Anomodon*, *Leskea*, *Cylindrothecium*, *Climacium*, *Hypnum*, we find equally identity or near affinity of forms for the species living on the ground, or on rotten, decomposed substances already nearly transformed into humus, while we have generally specific differences for the truly arboreous species.

There are indeed exceptional cases, apparently tending to weaken the prevalence of this rule. But I think that they might be easily explained if we were well acquainted with the true nature of the substances supporting mosses, and with the local influences which may act sometimes on their distribution. To exemplify this assertion, we may examine a few of those apparent exceptions. All the species of the genus *Sphagnum* live in bogs, and their existence is apparently depending on water only. We have, nevertheless, in Eastern North America, eight species different from those of Europe. But the water of the bogs where these mosses* are generally living is more or less impregnated with ulmic acid, resulting from the decomposition of wood, and there may be accordingly some chemical influence acting on the distribution of the species. Moreover, most of the exclusively American species of this genus belong to a warmer climate, or to a parallel of latitude where in Europe the destruction or the scarcity of the forests has prevented the formation of bogs. We have only two indigenous species: *Sphagnum cyclophyllum Sul. & Lesq.* and *Sphagnum sedoides Brid.*, with a northern range of distribution. They live either on the sand, or on granitic rocks, covered with water part of the year and en-

* According to Professor Schimper, the genus *Sphagnum* does not belong to the mosses, but to a separate family, the plants having a thallus like the Lichenes, and a conformation of their own.

tirely dry in summer. Hence, they periodically disappear, being apparently renewed each year from their thallus, and never reaching their entire development. They bear simple short stems, scarcely branching, and have never been found in fruit. It is evident that their presence, if not their form, is due to peculiar and local circumstances.

In the *Phascaceæ*, we have in Eastern North America five exclusively indigenous species of *Bruchia*. A single species of this genus has been found once only in the Vosges Mountains of Europe, at an altitude corresponding with that of the summit of Mount Marcy (about 6000 feet), on the decomposed dung of cows. Our *Bruchia flexuosa Schw.*, whose habitat I had opportunity to closely examine, is found in the spring in large round patches, apparently on the naked clay ground, but really at such places which were formerly covered by the dung of animals feeding in the meadows. The southern species have probably a habitat of the same kind, being found along the canals on the sand of the tow-paths. If this is the case, the distribution of these mosses is according to the general rule. The dung in various climatic conditions is the local habitation of different species of mosses. Our only true American *Splachnea*, *Tetraplodon Australis Sul. & Lesq.*, lives in the Southern swamps on the dung of mules.

The *Fontinales* are always found in water. The number of true American species, either on the east or on the west side of the continent, is pretty large, most of the species being truly arboreous. Indeed, they attach themselves to branches and roots of trees plunging in water, and occasionally only to stone. The few species which may be called *rock* species, generally attached to stones, like *Fontinalis Dalecarlica Bryol. Eur.*, are found both in Europe and in Eastern North America.

The genus *Dicranum* shows apparently another kind of anomaly of distribution, that is, identity of forms and variety of habitat. Twenty-seven of our Eastern North American species are the same as in Europe, though some of them are truly arboreous. All the arboreous ones live on rotten or decayed wood in the spruce region. The other species are mostly inhabiting the stones or the ground in the subalpine region, or the bogs. Their distribution is thus according to the common rule.

The affinity and also the modifications of forms following the influence of habitat, are better marked perhaps in the distribution of the genus *Orthotrichum* than in any other. The species living on rocks, *Orthotrichum Sturmii Hpp.*, *O. anomalum Hedw.*, *O. cupulatum Hoff.*, *O. Hutschinsiæ Grev.*, and also the subalpine arboreous species living on the bark of the spruce and the beech, *Orthotrichum Rogeri Brid.*, *O. speciosum Nees.*, *O. leiocarpum Br. & Schp.*, *O. Ludwigii Schw.*, *O. crispulum Hrsch.*, are identical in Europe and Eastern North America. On the contrary, the true arboreous species of the plain or of the temperate zone, *Orthotrichum exiguum Sul.*, *O. Texanum Sul.*, *O. strangulatum Beauv.*, *O. Canadense Br. & Schp.*, are exclusively indigenous. One of our Orthotricha-

ceæ only, considered as a variety of Orthotrichum Lyellii, seems to have an exceptional distribution, inhabiting as it does the bark of trees of the temperate zone. This would perhaps prove that this variety, as Hampe will have it, is a true American species. The name of *O. papillosum Hmp.* is well adapted to it.

It would appear that there is in the composition of some stones, peculiar substances which may affect the distribution of the mosses. Two Eastern North American species of *Desmatodon* live, one exclusively on conglomerate sandstone, the other on old bricks. Our indigenous species of small *Fissidens* are found also near the water on sandstone, either rolled in the creeks or cut for constructions, except *Fissidens subbasilaris Hedw.*, a true arboreous species.

It is perhaps to this predilection of some mosses for a peculiar kind of stone, that we owe in our temperate climate the presence of *Eustichium Norvegicum Bryol. Eur.*, inhabiting the conglomerate sandstone of Southern Ohio and Southern Kentucky, and considered by European bryologists as an exclusively northern species.

We might perhaps look for a third cause influencing the geographical distribution of the mosses, in the peculiar tendency of nature of associating in the same region similar forms, nearly allied species or may be varieties. Whatever might be the manner of explaining this grouping, it exists for the mosses far more evidently than for the phænogamous plants. Thus we have here, three species of *Cryphæa*, two of *Leucodon*, three of *Leptodon*, seven of *Anomodon*, three of *Thelia*, three of *Pylaisæa*, six of *Cylindrothecium*, and a great number of *Hypnum*, &c., whose specific characters are sometimes blended together in a way truly perplexing for the examiner. Even these specific differences can be sometimes followed on plants living in close proximity, and their cause apparently traced to natural variations of habitat. The *Theliæ* live generally attached to the smooth bark at the base of both *Carpinus Americana Mich.* and *Ostrya Virginica Willd.* Now *Thelia hirtella Sul.*, with simple papillæ on the back of the leaves, is found higher on the trunk. When it descends on the uncovered roots and becomes more exposed to the sun, the color is grayish, the papillæ are bilobed at the apex, there is a difference in the peristome, and we have indeed another species, *Thelia asprella Sul.* Southward, in Kentucky and Tennessee, this *Thelia asprella* is seen sometimes attached to small roots plunging in the sand. From the roots, the moss itself passes to the sand, becomes fixed to the ground, is now different in some characters, areolation and peristome, and a third species, indeed, *Thelia Lescurii Sul.*, apparently due to the influence of another habitat. Such imperceptible changes of forms corresponding with progressive variations, might be followed in the same manner, in other genera, especially in the species of the genus *Cylindrothecium.* But this examination would be now of small value; for without long and experimental researches, our belief in the influence of external circumstances of habitat on the form, can be but merely conjectural.

ARTICLE II.

ON THE MATHEMATICAL PROBABILITY OF ACCIDENTAL LINGUISTIC RESEMBLANCES.

BY PLINY EARLE CHASE, M.A.

Read September 18, 1863.

Most of the philological research of our day rests exclusively on a grammatical basis. The results that have been attained by such men as Edwards,* Schlegel, Bopp, and Grimm, cannot be too highly estimated, but their labors have been confessedly restricted within narrow boundaries, and they can be properly regarded only as preliminary, or introductory. The process of grouping languages into families, has already been extended nearly to its utmost practicable limits, and the question of connection between the families themselves, where no grammatical analogy can be discovered, must be solved, if it can be solved at all, by a comparison of radical words or syllables. Such comparisons have fallen into some disrepute for four principal reasons, viz.:

1. The progress of philology has brought to light old national affinities that had been previously unsuspected, showing that instances of supposed dialectic parentage were merely relations of fraternity or consanguinity, and many of the verbal derivations of the early etymologists have been consequently discarded.

2. Radical philology is a new science, and like most new sciences it has sometimes suffered from hasty generalizations, which, added to the occasional mistakes of enthusiasts, have brought undeserved reproach upon the whole study.

3. The natural desire to generalize results, has given rise to crude theories, some of which have been easily overturned, and others have been feebly propped by unsound or inconclusive arguments.

4. An undue importance has been sometimes attached to superficial analogies, and plausible grounds have thus been given to pretentious sciolists, for the summary dismissal of any newly discovered resemblance, by branding it as fanciful or accidental.

Let us give a brief passing glance at each of these points.

1. The old etymologies that have been discarded, have not, thereby, been rendered

* See Haven's *Archæology of the United States*, p. 55, for some remarks on the anticipation of Schlegel's idea, by Jonathan Edwards and others.

worthless. On the contrary, most of them have gained a new value, since they not only serve to strengthen the most important conclusions of comparative grammarians, but they also furnish a rich mine for the exploration of the searchers after verbal roots. Although it may be demonstrated that a given Latin word was not derived from the Greek, as was once mistakenly believed, the resemblance which led to the mistake still remains as an evidence of kindred origin, and if it be rightly studied it may help us to useful results. Although the French word *suivre* is undoubtedly more closely associated with the Latin root *sec*, than with the Chinese *suy*, the latter may possibly have arisen from a similar law of verbal detrition.

2. The unfair advantage that has been taken of the confessed errors of etymologists, will undoubtedly, in time, be followed by a favorable reaction, and meanwhile it will have little influence in deterring those who are on the lookout for new discoveries. The unfairness is in itself an evidence that the science which is impugned is still in its infancy, and that its field is consequently mostly unexplored. Therefore, as soon as the fact becomes established that there is a sure basis for accurate research, the great probability of attaining satisfactory results will draw crowds of investigators.

3. Students who have devoted themselves the most earnestly to philology, have been the most thoroughly convinced that all languages exhibit bonds of connection which point to a common origin of some kind. The more profound their research, the deeper does this conviction usually become, and it is no mark of a candid spirit, for one whose acquirements are not such as to qualify him for pertinent criticism, to charge it to the fascination of a hobby, or of a pet theory.* Such a charge might merit consideration, if the conviction were solitary or exceptional, or if it were made the main support of a questionable hypothesis. But its approach to universality should be regarded as sufficient evidence that it is well grounded, while the different reasons that have been imagined by different investigators to explain the connection, show that they have not been led astray by devotion to a system. Whether any of their theories be rejected or believed, the facts on which they were built are incontrovertible, and deserving of careful scientific investigation.

* I am aware that some distinguished scholars, like M. Renan, deny the existence of any traces of linguistic unity, but such a denial can have little weight with any one who is at all familiar with the profound researches of the German philologists. The *a priori* probability that there was a primitive significance to every syllable, and even to every sound, and that traces of such significance are still to be found in the languages which Max Müller has classed as "Turanian," is greatly strengthened by a comparison of such dialects as the Chinese, Egyptian, and Yoruban, and it seems to me much more natural and reasonable to regard identical roots as evidences of family identity, than to attempt to explain their existence in any other way.

4. The objection to fanciful or accidental resemblances, while it is the one most frequently urged, is also the most plausible, and I have thought it worthy of a brief examination, which has led to conclusions surprising even to myself, well prepared as I was, by twenty-five years' study of radical philology, to admit the truths of which those results are the natural indications. I had supposed that an argument on which so much stress is laid, one which is urged so often and so triumphantly, must have some claims to respect, but I find that a purely and strictly accidental coincidence* in sound and sense, is nearly, if not altogether, impossible.

For, in the first place, we must reject from the category of casual resemblance, all words that are determined by fixed and known laws; such, for example, as indicate nothing more than a uniformity of idea or of vocalization, that is dependent on a uniformity of human nature in its mental and physical constitution, and all words which are clearly or even probably derived from an onomatopœia. Words of the latter class are probably not so numerous as is often supposed, and even those which may possibly have had an onomatopoetic source (as *e. g.* Eng., *beef;* Fr., *bœuf;* Lat. *bov;* Gr., *βου*; Chin., *moo*), are often so transformed that their origin can only be made evident by a series of connected derivations, which serve to strengthen a conviction in the original family union of nations that are now most widely separated.

Let us then suppose that in two languages which we wish to make the subjects of comparison, all words of a merely imitative character, and all other analogues that could be reasonably referred to uniformity of organization, have been discarded. Suppose, moreover, that for other quasi-accidental and unknown reasons, there still remains a degree of resemblance so incredible that there is a precise correspondence between all the ideas represented in the two languages, and a correspondence equally precise in the sound of two-thirds of the words that they employ. Still, the word that denotes *boy* in one language, will be more likely to denote *horse*, or anything else rather than *boy*, in the other, and a single instance of merely fortuitous coincidence will be improbable. If the resemblance is still more striking, so that together with the correspondence of ideas, there is a precise agreement in the sound of *all* the syllables and words, there will probably be a single coincidence, and no more.

Some of the results of the following discussion have been anticipated by Dr. Thomas Young (Phil. Trans., 1819, p. 79, sqq.), but the importance of the subject seemed sufficient to warrant a more general investigation.

* In the present paper, I use the term *coincidence*, merely to denote words in two different languages which agree both in sound and meaning.

We will first examine the simplest case, in which there are m identical words, and m identical meanings in the two languages.

Suppose the words are similarly arranged in each language. Then, among the possible permutations of the meanings, there is only one in which they will all coincide, and none in which m—1 will coincide.

If all but two coincide, those two must change places. There are, therefore, as many such arrangements as we can make selections of 2 out of m, or, $\frac{m\ (m-1)}{2}$.

If all but three coincide, those three must change places in such a way that neither will occupy its original place. This can be done in two ways with each group of 3, and there are, therefore, twice as many such arrangements as the number of selections that we can make of 3 out of m, or, $2\times\frac{m\ (m-1)\ (m-2)}{3!}$

Tabulating and differencing these results, it will be seen that the number of arrangements in which there are n displacements out of m, is $\triangle^n\ 0!\frac{\times m\ldots(m-n+1)}{n!}$

The value of this expression can be readily ascertained, for

$$\triangle^n 0! = \frac{n!}{0!} - \frac{n!}{1!} + \frac{n!}{2!} - \cdots$$

$$n\triangle^{n-1} 0! = \frac{n!}{0!} - \frac{n!}{1!} + \frac{n!}{2!} - \ldots (-)^{n+1} 1$$ Hence, by subtraction,

$$\triangle^n 0! = n\triangle^{n-1} 0! (-)^n 1$$

There will ∴ be m displacements, or 0 coincidences, in $\triangle^m 0! = \frac{m!}{e} = .36788\ m!$ arrangements, leaving for the probability of one or more coincidences, .63212 $m!$ out of $m!$ possible arrangements,—which is a probability of about $\frac{5}{8}$. There will, therefore, probably be at least one coincidence.

There will also be m—1 displacements, or 1 coincidence, in .36788 $m!$ arrangements. Deducting this amount from .63212 $m!$ there remains only a chance of $\frac{26424}{100000}$ for more than one coincidence. If the words, and also the meanings, were identical in two languages, there would ∴ probably be 1 accidental coincidence, and no more, as stated above.

In order to investigate the other supposed case, it will be necessary to consider the more general expression, $\triangle^n\ m!$, the value of which can be conveniently ascertained in two ways. For,

$$\triangle^n\ m! = \triangle^n\ (1+\triangle)^m\ 0!$$

$$= \left\{\frac{\triangle^n}{0!} + \frac{m}{1!}\triangle^{n+1} + \frac{m\ (m-1)}{2!}\triangle^{n+2} + \ldots \triangle^{m+n}\right\} 0! \qquad (1)$$

or, $\triangle^0\ m! = m!$ A

$\triangle^1\ m! = m.m!$ A′

$\triangle^2\ m! = m\ \mathrm{A}' + \mathrm{A} + \mathrm{A}'.$

$= (m+1)\ \mathrm{A}' + \mathrm{A}.$ A″

$$\triangle^3 m! = (m+1)\ A''+A'+A''+A'.$$
$$= (m+2)\ A''+2\,A'.$$
$$\vdots \qquad \vdots$$
$$\triangle^n m! = (m+n-1)\ \triangle^{n-1} m!+(n-1)\ \triangle^{n-2} m! \qquad (2)$$

If we compare two languages in which there are m identical meanings, and only $m-n$ identical words, there will evidently be no arangements that admit of m, $m-1$, ...$m-n+1$ coincidences.

The $m-n$ words will retain their position in $n!$ arrangements.

There will be $m-n-1$ coincidences in $\triangle n! \times (m-n)$ arrangements. And, generally, there will be $\frac{(m-n)\ldots(m-n-r+1)}{r!}\triangle^r n!$ arrangements, which admit $n+r$ displacements, or $\triangle^{m-n} n!$ arrangements in which there will be m displacements, and 0 coincidences.

In order to ascertain when the chance of a coincidence is less than $\frac{1}{2}$, and therefore cease to be a probability, we have

$$\triangle^{m-n} n! > \frac{e \triangle m\, 0!}{2};\ \text{or, by (1)}$$
$$> \triangle^{m-n} 0! + \frac{n}{0!}\triangle^{m-n+1} 0! + \ldots \frac{n}{0!}\triangle^{m-1} 0! + \triangle^m 0!$$

The ratio of n to m that will satisfy this inequality, may be found by making $\frac{m!}{2} = \triangle^m 0! + n\ \triangle^{m-1} 0! + \ldots$ &c. Assuming 10 as a convenient value for m, extending the right hand number to four or five terms, and solving the equation, we obtain the corresponding value, $n=3.185$; or, as the ratio is independent of any particular values, $n=.3185\ m$. $m-n=.6815\ m$. $\therefore$ If the number of identical words is less than .6815 of the entire number of words in each language, any accidental coincidence would be improbable. Q. E. D.*

The likelihood is not changed by any possible multiplication of the number of distinct ideas that a language may contain. For, if there are mn separate notions, to be represented by n words, while each word will have an average of m meanings, the probability of any single meaning being assigned to any particular word, is $\frac{m}{mn}$. This is precisely equivalent to $\frac{1}{n}$, which is the like probability when the number of notions is only n.

On the other hand, an increase in the number of meanings manifoldly increases the

* As a case in point, I would refer to the Cherokee alphabet. Its inventor, Sequoia, had seen our alphabet, but was ignorant of the phonetic value of any of the characters. He modified the forms of F, O, Q, U, and V, and employed, without any alteration, all the other letters except N and X, using each letter to represent a syllable. Only one of his characters has a value at all resembling our own; the letter L, which stands for the syllable TLE. This half-coincidence admirably exemplifies the calculated probability that there would be one coincidence and no more, and the equally divided chance between a single coincidence and no coincidence. The alphabet in question is given in *Schoolcraft's History of the Indian Tribes*, vol. 2, p. 228.

probability of a common origin, when the words compared present a coincidence in more than one of their meanings. For, if the concurrent meanings are apparently derived from a single primitive, we have the case which has been long and generally recognized as strengthening the evidence of family connection,—the case of parallelism in thought, which comes next in point of importance to parallelism in grammatical forms; while, if the meanings are radically distinct, the probability of each successive coincidence is diminished in a geometrical ratio, the chance of a second being only $\frac{1}{n^2}$,—and of m simultaneous coincidences, only $\frac{1}{n^m}$. Therefore, although it is desirable to ascertain the primitive or radical signification of words, before instituting a comparison, it is not absolutely essential, neither is it even so important as it is often thought.

But what can be said of synonymes? Is it not probable that when the number of verbal equivalents becomes large, the number of accidental resemblances will be proportionally large? Here, if anywhere, is the stronghold of the believers in casual similitudes, but even here their position may be easily assailed.

Granting, as before, for the influence of known and unknown laws, that two given languages represent the same ideas, and are also homonymous, the meanings being allotted to the several words at random, let us further suppose that each idea is attached to m synonymes in each language, the entire number of words being n. If the synonymes of a given idea in one language are $\alpha, \beta, \gamma, \ldots \mu$, we shall still have no probable grounds to expect that either of these words will represent the same idea in the other. For the chance of the given idea being represented by any single word in the other language being $\frac{1}{n}$, the chance of its being represented by some one of the m homonymous words is $\frac{m}{n}$, which does not become a probability until $m \geqq \frac{n}{2}$, a degree of synonymy that is wholly incredible.

Finally, if the m words in the first language are not only synonymes of a single idea, but perfect equivalents that may be taken indiscriminately, each of the words $a, b, c, \ldots m$, being defined by the same set of ideas, $\alpha, \beta, \gamma, \ldots \mu$, the chance of a coincidence between some one of the m ideas and either of the m homonyms in the other language, would be $\frac{m^2}{n}$, which becomes a probability when $m \geqq (\frac{n}{2})^{\frac{1}{2}}$.* But even in that case, the chance of a second coincidence on the same word, would be only $\frac{m}{n} \times \frac{m^2}{n}$, which is less than a probability.

That the change of form which the words of every living language are constantly undergoing, has no effect on the probability of accidental resemblance, is evident from the fact that all our reasonings have been of the most general character, and they may be applied to any languages whatever, without regard to their family relationship, their present

* There would still hardly be a likelihood of more than one coincidence among all the homonyms. For the chance of such a coincidence would be indicated by $m \times \frac{m^2}{n}$, which does not become a probability until $m \geqq (n)^{\frac{1}{3}}$.

or past condition, their relative antiquity, or any other incidental circumstances. Whenever, therefore, in the course of our linguistic comparisons, we discover any marked similarity both in sound and sense, it may safely be assumed that the resemblance is not accidental, but that it results from the operation of some adequate cause. Although, in many cases, that cause cannot be positively ascertained, we may often satisfy ourselves as to its probable character.

For example, let the subject of comparison be the Chinese Mandarin root ma¸g, or mi¸g, which denotes "great, vast, confused, mixed," and other similar meanings. As analogues, we find in Sanscrit ma¸h, to grow; mah, to honor; ma′h, to measure; macf, to collect, to fill, to mix; with the derivatives mahat, great, mighty, &c.; in Greek, *μάγγανον, μάγος, μάχαρ, μαχρός, μάλα, μέγας, μίγνυμι, μιξ;* in Latin, *magister, magnus, misc, mix, majestas, mango;* in Gothic, *mickels;* Ang. Sax., *maegn, micel, mucel;* Swedish, *mycken;* Scotch, *mekyl, muckle, myche;* Spanish, *mucho;* English, *mingle, mongrel, mix, much;* in old Egyptian, mah, to fill; mak, to rule. The common ancestry of the Sanscrit, Greek, Latin, and Gothic dialects, is now generally admitted, while the affinity of the Chinese is still a mooted question. The chance for a merely fortuitous resemblance in the Chinese radical, may be determined in the following manner.

There are in the Mandarin dialect, eighteen initial sounds, seven which may be either medial or final, and only four which can be used as final in connection with a medial. The respective chances of accidental concurrence on the several sounds are, therefore, $\frac{1}{18}$, $\frac{1}{7}$, and $\frac{1}{4}$, and the chance that the concurrent sounds should be similarly arranged, is $\frac{1}{3!}=\frac{1}{6}$. The chance of the entire coincidence is only $\frac{1}{18}\times\frac{1}{7}\times\frac{1}{4}\times\frac{1}{6}=\frac{1}{3024}$, and it is, therefore, morally certain that the resemblance is not accidental.

The efficient causes which are most frequently set forth to explain such resemblances, are those which have already been intimated, viz.: 1. Uniformity of physical organization; 2. Uniformity of mental action; 3. Imitative nomenclature, or onomatopœia; 4. Affiliation of languages. The first may be deemed sufficient to account for a resemblance in the elementary sounds, and the second for a similarity of ideas, but neither separately nor in combination is it easy to conceive of their determining the assignment of special sounds to the expression of special ideas.

There is no plausible onomatopoetic explanation for any portion of the word except the broad vowel *a*, which, if we set aside as being thus sufficiently accounted for, the chance of casual coincidence is increased to $\frac{1}{3024}\div\frac{1}{4}=\frac{1}{756}$. Although it is possible, and perhaps even probable, that the other sounds may also have been primitively onomatopoetic, we have no right to take it for granted that they were so; and even if they were, the fact would neither diminish any probability of a common origin that might be advocated on other grounds, nor would it explain the precise arrangement of sounds which has been adopted.

There would still remain an odds of five to one against that particular arrangement, which might be readily and most satisfactorily overcome, by supposing that the root in question had been handed down to each language from some older and extinct dialect. That this is the true solution of the problem, is rendered still more likely by the following considerations.

1. Although the Chinese is entirely destitute of grammatical inflections, and it is, therefore, impossible to subject it to any grammatical comparisons, except such as are merely syntactical, its syntax, as Chev. Bunsen has demonstrated, is clearly of the Aryan type.

2. The Mandarin dialect has no final gutturals, but the terminal ˛g is often replaced by a guttural in the other dialects. Thus, the mandarin word pa˛g, to bind, to tie, becomes pak in Hok-Këen, and is thus naturally associated with Sanscrit pag, paſ, Greek, *πάγ—*, *παχ—πήγν—*, Latin, *pang*, *pac*, *pax*, Ger., Eng., and Sw., *pack*, in the same way that ma˛g is connected with a *μαχ—*, *μεγ—*, *mag—*, *magn—*, &c.* Hok-Këen being in the southeast quarter of the Chinese empire, closer resemblance to the Aryan forms would naturally be expected, and the discovery of that resemblance greatly strengthens the probability of a common origin.

3. The broad vowels are often degraded in Chinese, as well as in the Aryan languages. E. g., pa˛g, ma˛g, become respectively pi˛g, mi˛g, without losing their primitive meaning or producing any change except a greater specialty of application. So in Latin, *pang-o*, *imping-o ;* English, *mong-rel*, *ming-le.*

4. The Mandarin root ma, to add to, to increase, which may either be the primitive from which ma˛g was derived, or an abbreviated form of the latter word, is found in *μάλα.* The double sense of greatness and seniority, is common both to Latin *major*, and Chinese ma˛g.

From the cumulative evidence that I have thus briefly presented, I am unable to draw any other conclusion than that the Chinese and Aryan words here given, have a common origin. And finding, as I do, that comparisons equally striking, can be made with nearly every Chinese root, I can readily believe, with Bunsen and others, that the Chinese is the oldest language of which we have any record, "the monument of antediluvian speech."

I have purposely based my calculations upon assumptions the most favorable that I could imagine, for the production of abnormal resemblances. Every deviation in any of the hypothetical postulates, such as new evidence of pre-historical national intercourse, an increase in the number of similar roots which are traceable in different families of languages, well-sustained philosophical generalizations which lead to just methods of philological study, the discovery of a new law of verbal derivation or transformation, while it may have some tendency to complicate the problem, has a still greater tendency to render its

* The Hok-Këen word mi˛g, an incantation, similarly serves to connect the root ma˛g, with *μάγγ-ανον*, magus, &c.

further investigation unnecessary, because it diminishes, in a rapidly increasing ratio, the chances for merely accidental analogies.

We may, therefore, safely assume that any single coincidence in words of two or more syllables, or any two coincidences in radical syllables, furnish almost irresistible evidence of a national intercourse to which the coincidence is attributable. The presumption is greatly increased by every additional coincidence of either kind, and if the concurrence is frequent, or if it extends alike to derivatives and primitives, the hypothesis of mere national intercourse, by commerce or conquest, becomes less satisfactory, and it is difficult to imagine any sufficient explanation other than a common genealogy. As there are no two known languages which are destitute of a large number of such coincidences, the *à posteriori* evidence of a unity of language appears to be stronger than that of a unity of race.

Any considerable number of accidental coincidences being, as we have shown, not only improbable but morally impossible, the reasonable effort of a just philosophy, whenever they occur, is to search for some law by which they can be satisfactorily explained. By such a search, carefully conducted, philology may gradually be placed on a "positive" basis. It is certain that no adequate explanation has yet been offered for the various linguistic phenomena, except that which is based on common descent, and if none other should be found hereafter, the believers in the specific unity of man, whether upon scriptural, historical, psychological, or mere philosophical grounds, may well be gratified at such strong confirmation of their views.

ARTICLE III.

ON THE COMPARATIVE ETYMOLOGY OF THE YORUBA LANGUAGE.

BY PLINY EARLE CHASE.

Read September 18, 1863.

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ABBREVIATIONS.

A. Arabic.	Du. Dutch.	Gr. Greek.	S. Sanscrit.
Arm. Armoric.	Eg. Egyptian.	H. Hebrew.	Sc. Scotch.
A. S. Anglo-Saxon.	Eng. English.	I. Italian.	Sh. Shyenne.
Bl. Blackfoot.	F. French.	Ic. Icelandic.	Sp. Spanish.
C. Chinese.	Fi. Finnish.	I. G. Indo-Germanic.	Sw. Swedish.
Co. Coptic.	G. German.	Ir. Irish.	T. Turkish.
Cr. Crow.	Ga. Gaelic.	L. Latin.	W. Welsh.
D. Dakota.	Go. Gothic.	P. Pawnee.	Y. Yoruba.
Dn. Danish.			

1. If the reasoning is correct, by which I have attempted to demonstrate the improbability of accidental resemblances in language, our next question will naturally be, what are the probable causes of the resemblances that we find actually existing between dialects the most widely separated, spoken by nations between whom there has been no historical intercourse?

2. Various hypotheses have been framed in answer to this inquiry, but as none of them are so general and satisfactory as that of family affinity, they are deserving, merely as hypotheses, of but little consideration. Even granting them all the importance that their

advocates can possibly claim, and setting aside everything for which their explanation is admitted to be sufficient, there still remains an unsolved residuum, which can be accounted for only on the simple and all-sufficient supposition of a common origin.

3. But, however satisfactory any hypothesis may be, the need of stronger assurance will be constantly felt, and every road that promises any approximation to certainty, should be carefully explored. The three obvious avenues for research in language, are, 1. Historical intercourse between nations, by conquest, colonization, or commerce; 2. Resemblance in verbal forms, whether radical or derivative; 3. Analogies in grammatical inflection and construction. All immediate, or derivative etymology, is based upon the evidence of national intercourse, while all comparative, as well as all radical etymology, rests on the formal resemblances and normal differences of words. Grammatical analogy, when strongly marked, furnishes nearly demonstrative evidence of a common lineage, and it should, therefore, be the first object of search in all philological comparisons.

4. If the grammatical resemblance is decided, it adds great weight to every verbal resemblance; if it is feeble, doubtful, or entirely wanting, it has hitherto been often assumed that coincidences of sound and meaning may be accidental. I have endeavored to show that this assumption is entirely groundless. The absence of inflectional counterparts, can, at the best, prove no more than that there has been no family intercourse since the inflections were established; and it is difficult to understand why more weight should be given to mere verbal identity or similarity in one case than in another, or why different explanations should be sought at different times for resemblances of the same character.

5. The early etymologists generally pursued their inquiries under an impression that the parent language was still extant. The honor of parentage has been successively attributed to Hebrew, Chinese, Egyptian, and Sanscrit, but these successive claims have all been strenuously disputed, and the believers in radical primitives no longer confine their investigations to a single channel. Still, the question of the relative antiquity of languages retains its interest, and every new discovery of collateral evidence that has even an indirect bearing on the question, is eagerly welcomed.

6. The publication of Bowen's Yoruba Grammar and Dictionary, in the Smithsonian Contributions of 1858, has furnished to comparative philologists a new and valuable Thesaurus of radical words and primitive grammatical forms, the study of which may, perhaps, do much towards removing the difficulties that have hitherto impeded the progress of philological science.

7. The Yorubas occupy a portion of Western Africa lying between 2° and 7° E. long., and between 6° and 9° 30′ N. lat. Their territory is bounded on the north by Barba and Nufe, east and southeast by the Niger and Benin, south by the Gulf of Benin, and west by Dahomey and Mahi. They are usually black, and have woolly hair, but individuals

are sometimes met with "who are fully as light-colored as the American Indians. This color is hereditary in certain families; and it is a curious fact that, although it may seem to be lost, it sometimes reappears in subsequent generations. Individuals of this color are found not only among the Yorubas and other tribes of the interior, but among the Iboes, and even among the Kroomen. They are called 'red men' in Africa, though their color is not exactly that of Indians, nor yet of mulattoes, and is something wholly distinct from albinism. Several entire tribes of red men are found in the interior. The people of Ilorin spoke of a tribe of pastoral people called Alabawo, 'Hide-wearers,' who are said to be decidedly light-colored. They build no towns, but live in leather tents, which they pitch in the form of a circular village, and remove from place to place for the sake of pasturage.

8. "It seems reasonable to suppose that the red men among the Yorubas had the same origin as the red Pulohs and other red tribes of the interior. On the other hand, it is unnecessary to refer the light color of these people to climate, or to other conjectural causes, when we have good evidence that an extensive amalgamation of the black and white races has taken place in the countries where most of the mulattoes are now found. We may admit in advance that some of the evidence of this amalgamation may be spurious or doubtful. For instance, King Belo, of Sokoto, may be mistaken, when he asserts in his history of Takroor that Bornu was peopled by an Egyptian colony. Still it is undeniable that a strong Caucasian intermixture extends from the Red Sea through Nubia and Darfur to the Shoas, southwest of Lake Tsad; and it is just here, at the last-named point, that we first meet with the red Pulohs, who extend through Hansa, Bambara, &c., to the Senegal and the Atlantic Ocean. . . . It is a curious fact that some of the Pulohs at Ilorin are lighter colored, and more of the white man in every respect, than any half-blood mulatto I have ever seen either in America or Africa."*

9. That the ancient inhabitants of Yoruba had commercial intercourse with Egypt, is rendered almost certain by the fact that "segi," a kind of ancient Egyptian beads, are dug from the earth at Ife and other places. King Belo's assertion renders it probable that the red Pulohs may be descended from the red race of nobles that is depicted in the Egyptian monuments, and in my opinion this probability is increased by the certain antiquity of the red race in America, by the apparent association, among many ancient nations, between the ideas of man and redness,† by the leather tents of the Alabawo, which may indicate

* Bowen's Grammar and Dictionary of the Yoruba language, pp. xiv–xv. I am indebted to Mr. Bowen's work for all my information respecting the Yorubas and their language.

† *E. g.*, אדם; Egyptian, ruma, rt, *man;* r, (denoting redness or brilliancy), in the words that signified *sun, evening, heat, to burn, a flower;* Yoruba, okoŋri, *man;* obiri, *woman;* (ako re, *the red male;* obi re, *the red female;*) Dakota, wićas'ta, *man;* (wića, *male;* s'a, *red;* staŋ, or s'taŋ, *purple, dark;*) Gr., *ἀνθρ-ωπος?* Clarkson, in his "Essay on the Slavery and Commerce of the Human Species" (3d Ed., Phila., 1787, p. 120), gives plausi-

an etymological connection between the Hebrew בת and Yoruba bata, *a hùle*, by the Yoruba traditions,* and by the marvellous grammatical affinity (which I believe no one has previously noticed), that exists between the Yoruba, Egyptian, and Coptic languages. This confirmed probability adds so great weight to one of the strongest arguments in favor of linguistic unity, that I cannot refrain from quoting, in this connection, Max Müller's admirable statement of that argument.

10. "Now, if we consider the large number of tongues spoken in different parts of the world, with all their dialectic and provincial varieties, if we observe the great changes which each of these tongues has undergone in the course of centuries, how Latin was changed into Italian, Spanish, Provençal, French, Wallachian, and Roumansch; how Latin again, together with Greek, and the Celtic, the Teutonic, and Slavonic languages, together likewise with the ancient dialects of India and Persia, must have sprung from an earlier language, the mother of the whole Indo-European or Aryan family of speech; if we see how Hebrew, Arabic, and Syriac, with several minor dialects, are but different impressions of one and the same common type, and must all have flowed from the same source, the original language of the Semitic race; and if we add to these two, the Aryan and Semitic, at least one more well-established class of languages, the Turanian, comprising the dialects of the nomad races scattered over Central and Northern Asia, the Tungusic, Mongolic, Turkic, Samoyedic, and Finnic, all radii from one common centre of speech; if we watch this stream of language rolling on through centuries in these three mighty arms, which, before they disappear from our sight in the far distance, clearly show a convergence towards one common source: it would seem, indeed, as if there were an historical life inherent in language, and as if both the will of man and the power of time could tell, if not on its substance, at least on its form."†

11. The third of these "mighty arms," appears to have had a pre-Semitic branch, which traversed the whole breadth of Africa. The researches of Champollion, Lepsius, Bunsen, and others, have demonstrated the Turano-Semitic affinities of the monumental Egyptian, and Mr. Bowen's work enables us to discern widely extended ramifications of those affinities which were previously unknown.

ble reasons for supposing that the original complexion of man was olive, and that the change has been in one direction to brown and white; and in the other, to red and black.

$$\left.\begin{matrix}\text{"White,}\\ \text{Brown,}\end{matrix}\right\} \text{ Olive, } \left\{\begin{matrix}\text{Copper,}\\ \text{Black."}\end{matrix}\right.$$

* "The traditions of the Yoruba people as to the origin of their tribe, are obscure and contradictory. They generally affirm that mankind were created at Ifè, a considerable town in the eastern part of the Yoruba country. Sometimes they speak of Ifè as being four months' journey distant, as though the present town of that name were confounded with some other place, of which the people retain an obscure traditional recollection. . . . I have been informed by some intelligent natives, that the Yoruba people once lived in Nufe, beyond the Niger."—*Bowen*, p. xv.

† Lectures on the Science of Language. First American Edition, pp. 42–3.

12. The Yoruba language, "which is surprisingly rich in abstract terms,"* is of a very early Turanian, or agglutinative type. To me it seems little less than miraculous, that a barbarous people should have so long retained in its entire speech, the clear traces of its whole radical vocabulary, and with so little appearance of phonetic decay.

13. "The primitive words of the Yoruba language, amounting in all to about five hundred, consist of the following classes:

"1. Personal and other pronouns.

"2. About one hundred and sixty verbs, several of which are obsolete.

"3. About two hundred and fifty nouns, including several which are clearly exotics.

"4. A few particles, as adverbs, prepositions, conjunctions, and interjections.

"The remainder of the language, amounting to at least fifteen thousand vocables, has been built up on this foundation, chiefly by prefixing personal pronouns to verbs to form nouns, and by the union of nouns with verbs and prepositions.

14. "The primitive verbs are all monosyllables, and most of them are of the simplest possible form, consisting of a single consonant, simple or compound, and a vowel, either pure or nasal.

"A few monosyllabic verbs begin with two consonants; as, mbè, *to be;* nlà, *to be large*, &c. These, however, are secondary forms. . . . .

"The verbs of two syllables are all either derivatives or exotics. . . . .

"Very few of the exotic words have come to the Yoruba people through the Arabic; and it is remarkable that some words of undoubted Eastern origin are unknown among the tribes further in the interior."†

15. "There are three primary tones, the middle, the acute, and the grave; as ba, *to melt;* bà, *with;* and bá, *to bend*. The middle is the ordinary tone of the voice without inflection; the acute and grave tones are simply the rising and falling inflections of elocutionists. In the Yoruba language, however, they are employed to distinguish words which are spelled alike, but have different meanings. Thus, the two words obé, *sauce*, and obè, *a knife*,‡ are quite different to the ear, when uttered with the proper tones. The tones, though simple in theory, are difficult for us to seize, and require close attention."§

16. In all the particulars here enumerated, more especially in the monosyllabic character and simple form of the primitive verbs, and in the peculiar intonation, there is so striking an analogy to the genius of the Chinese language, that any additional evidence of affinity between the two dialects, instead of awakening any surprise, might be readily received as the fulfilment of a natural expectation. In one respect, the Yoruba is the simpler language, for the only suffix that it admits for the vowel of any syllable, is the guttural nasal ṇ, while

* Bowen, p. xx.

† Ibid., pp. 10–11.

‡ We also speak of a *sharp* sauce, as well as of a *sharp* knife.

§ Bowen, p. 5.

the Chinese allows the employment either of the guttural nasal, or of the dental nasal, *n*. This difference, however, is so slight, that it does not materially affect the general parallelism of structure, but the two dialects stand side by side, as the best living representatives of the earliest types of speech, as well as of the rudiments of dialectic variation.*

17. The following pronominal or demonstrative elements, are found in Yoruba, viz.: a, e, i, o, w, y, m, n, ŋ, k, t (and perhaps s, in the verb sa, *to aim or point at*).

1. For the pronoun of the first person; a, i, o, m, ŋ, w. E. g., emi, mo, mi, ŋ, *I;* à, awa, *we;* Cfr. ἐμέ, *mich, me, we, nos, ego, —o, —m;* Chin., *wo, go* or *ngo;* Egypt.,† a, u, anek, or anuk; Copt., anok, anak, anog; Heb., anokhi, i; S., **aham, vayam.**

2. For the pronoun of the second person, e, i, o, w, ŋ. E. g, iwo, o, *thou;* è, eŋyiŋ, *ye.* Cfr., *ye, vos;* S., **tvam, yuyam.**

3. For the pronoun of the third person; a, i, y, o, w, n, ŋ. E. g., oŋ, o, i, yi, a, *he, she, it;* à, awoŋ, nwoŋ, *they.* Cfr., ὁ, ὅς, *he;* Egypt., u or f; Heb., hu, hv, o.

4. For the indefinite pronouns; n, t, k, y, r. E. g., na, *that, the same, the;* ni or eni, *one, person, this, that, the;* ta? *who?* ti, *who, which, that;* kaŋ, *one;* k or ek, *the ordinal prefix;* ki? *what?* ki, (*conj.*) *that;* yi or eyi, *this;* re, *his, her, its, thy, him, thee.* Cfr., Egypt., anuk, entek, enta, entuf, entus, ek, et, su, se, es, ten, sen, &c.; Sans., **sa, tad, yad, tyad, etad, idam, ki.**

18. The number of pronominal elements, and the consequent number of their possible combinations, is so great, that one may be easily inclined, though "convinced against his will" of its intrinsic improbability, to bring forward the old argument of possible accidental resemblance. But such an inclination can hardly remain after a study of the comparative grammatical structure of the verbs in the Yoruba and Egyptian languages, which have the following features in common.

19. "The infinitive is the pure root. . . . . Now this root expresses at once all the persons, whether the subject precede, or, as is more commonly the case [in Egyptian], the sentence begin with the verb.‡

20. "Through all the variations of person, number, mood, and tense, the verbal root remains unchanged.§

* Dr. Prichard, in his Natural History of Man (3d London ed., p. 551), refers to the wide diffusion through Northern Africa, of tribes bearing an unquestionable affinity in language to the Syro-Arabian or Shemite race. He also notices the fact that the resemblances, especially in grammatical structure, are approximations not to the modern but to the most ancient dialects of the Semitic family. If the Chamitic resemblances should prove to be equally striking, African comparative philology may perhaps furnish the *experimentum crucis* that will finally settle the mooted question of linguistic unity. I give on a subsequent page some interesting comparisons with Dr. P.'s collection of South Sea Island words.

† Bunsen's Egypt's Place in Universal History. Ed. 1848, vol. 1, p. 283.

‡ Bunsen, vol. 1, p. 294.

§ See Bowen, p. 27 sqq., and Cfr., Bunsen, vol. 1, p. 294 sqq.

21 "Person and number are denoted by the form of the personal pronoun that represents the subject; E. g.:

"emi ri (Egypt., mau* a), *I see;* awa ri (Egypt., mau en), *we see.*

22. "The modes and tenses are indicated by auxiliary particles placed before [or after] the verb. The whole difficulty of the verb lies in the position and meaning of those particles; and thus the intricacies usually found in the inflexions of the verb are here transferred, as it were, to the department of syntax.

23. "There is but one conjugation, and [there are] no irregular verbs; all verbs being varied in the same manner.

24. "The use of ŋ or m in [Yoruba] conjugation, is to denote a continuing or unfinished action, or one which was unfinished at the time referred to." "To form the past tense (or perfect definite) in Egyptian, *en* is introduced between the subject and verb."

25. The future, in Egyptian, is formed by au r, or simply au (Copt. e), "esse versus," like the Italian "essere per," prefixed to the root. The same tense is formed in Yoruba by prefixing o to the root. Bowen thinks that this o was originally the personal pronoun, and that the expression emi o ri, *I shall see*, means literally, *I* am *he to see.* It seems to me more probable that o is an abbreviation of the Yor. substantive verb wa Egypt. au, which is perhaps, in its turn, the root of av or ab in habere, aver, avoir, (est mihi = habeo). The close coincidence of the demonstrative roots in Yoruba, with the various elements of the substantive verb, reconciles this opinion with that of Bowen, and also shows an identity of structure in the Egyptian, Yoruba, and Coptic futures, as well as in the French *aur-ai* (*avr-ai*), and Italian *avr–o.*†

26. The optative is formed in Yoruba by the particle ma (Chinese mang; Ger., *mag;* Eng., *may*), in Egyptian by mai. Both in Yoruba and Egyptian this particle expresses desire, as well as permission and possibility, as in the Latin *ma-lo*, Ger., *mag ich*, Eng., *may I*, and apparently for a similar reason. I *great* to go, may as fitly express an ardent wish, as I *long* to go.

27. "This form of expression [the optative] is much employed instead of the imperative, as being more courteous; as, ma kuro, *thou mayest get out of my way;* ò ma yara, *ye may make haste.*" The Yoruba imperative has three forms: 1. The simple root, as in English; ri, or iwo ri, *see*, or *see thou;* 2. The root preceded by ma, as in Egyptian; ma ri, or iwo

* The root ri, is found in the Egyptian iri, *eye*, but I know of no authority for its use in that language as a verb. The Egyptian *mau*, and the Chinese *muh* (Morrison, 7803), may be cognate. * In Coptic, as in Yoruba, the pronoun precedes the verb.

† The views here expressed are confirmed by the fact that the Y. verbs 'i, ni, ri, are used both in the sense of *to be*, and *to have*, and that the verb wa, *to be*, is used in the formation of the past perfect; e. g., emi wa ri, *I was seeing*, or *I saw.* Bowen says (Gram. p. 35), "the verb wa, *to be*, is used in all tenses; but there is a tendency to restrict it to the past." Cfr. E. was, L. –vi.

ma ri; 3. The root preceded by the conjunction and pronoun (Cfr., Lat., *videas*, *ut videas*); ki o ri, *or* ki o ma ri, *that thou see*, or *that thou may see.* The conjunction and pronoun are sometimes reduplicated, e.g.; ki iwo ki o ma ri, *that thou that thou may see.*

28. There are no participles except the verbal nouns, which are formed by the combination of the verbal root with the demonstrative elements. In Yoruba, the perfect participle is often represented by a verb with the prefix ŋ; by ki, *that*, and a verb,—or by a verb used impersonally; as, igi ti à gbiŋ (*tree which they planted*), *a tree planted.* The German *ge*, may perhaps be cognate with one of the first two forms, and the Latin *–tus*, Egypt., *–ta*, *–et*, *ente–*, with the third.

29. There is no proper form for the passive, but its meaning is expressed by various circumlocutions.

30. Presuming that this striking coincidence of grammatical forms will be deemed sufficient to prove that the affinity of Yoruba to Egyptian is even closer than to the Shemitic languages, and that we may, therefore, reasonably expect to obtain new lights for Egyptology and primitive philology from its careful study, I will give a few examples to illustrate its use in radical etymology.*

31. Dr. Prichard has brief vocabularies of South African† and Polynesian languages,‡ from which I select the following common words:

32. MAN.—1, mtu (plur., watu); 2, mutu (atu); 3, mundu (andu); 4, aito; 5, mtu; 6, uhmto; 7, motu; 8, mantu; 9, moontau; 10, mondu; Cfr. Dakota, mdoka; Egypt., *ka;* Chin., kung; Yor., ako; (ató, *guardian*). v. FATHER.

33. WOMAN.—1, mtumke; 2, mutshetu; 3, muka; 4, endangili; 5, mfiere; 6, umfasi; 7, massari; 8, mahe, mekonque; 9, kentou, quinto; 10, kentu. These words, like kindred terms in other languages, appear to be generally derived from the masculine terms by adding a root (k, g, h, sh, s, or f), expressive of gestation. Cfr. Yor., ka, *to fold;* ba, *to bend, to bind;* bi, *to beget, to bear;* bo, *to cover;* abo, *a female, a bag;* obi, *a parent, female;* Dak., wi, *to wrap around;* wi, *woman, female;* Eg. s, *she;* sak, sna, *to bind, to bend;* sapi, *to form, to create* (*schaffen, shape*); [b is also used in Egyptian words that denote bending, and baah = Yor., obo, *pudendum*]. Chin., foo, *to stoop, husk, store-house, wife; the female in nature;* we or wei, *to tie, to surround, a handsome woman;* Lat., *foemina;* Eng., *womb, woman, wife;* Ger., *weibe.*

34. FATHER.—1, 2, 4, baba; 6, bao; 3, atza; 5, dadi; 7, raacho; 8, tete; 9, tata, bantu;

* For a resumé of the general evidences of affinity between the languages of Eastern and Western Africa, see Prichard, p. 640 sqq.

† Page 651. 1, Suahali; 2, Wanika; 3, Wakamba; 4, Ukuafi; 5, Msegua; 6, Kosa; 7, Sichuana; 8, Mozambique; 9, 10, Kongo.

‡ Page 665–6. 11, Madecass; 12, Malayan; 13, Sandwich Islands; 14, Samoan and Fiji Islands; 15, New Hebrides.

10, tatta, tate. Cfr., אב; Yor., baba, oba; Dak., ate; Egypt., at, atai, atf or atu; Chin., foo, *father, elder, superior;* choo, *lord, master.*

35. MOTHER.—1, 8, 9, 10, mama; 2, maio; 5, mlela; 6, mao; 7, maacho; 3, ia; 4, yeya; Cfr. Yor., mo, *to build* or *form* of clay; amo (*that which moulds or is moulded*), *potter's clay, a child;** abiamo (*child-bearer*) *mother;* iya or yeye, *mother;* Dak., mama, *mother, a woman's breast;* Eg., mu (Cop., mau); Chin., moo, *mother, mould, form.*

36. SUN.—1, dshua; 2, dzua; 3, kua; 5, zua; 8, ezooah; 9, ezoolo; 10, sultu; 11, massou androu; 4, engolo; 6, ilanga; 13, ra, la, laa; 14, la, ginga, asth; 15, nangasnga; 9, tengua; 10, tunga. Cfr. Yor., odźó, *day;* mo, raŋ, taŋ, yaŋ, *to shine;* oruŋ, *sky, heaven;* oruŋ, *sun;* oro *or* owuro, *aurora, morning;* Egyp., la *or* ra, *sun, day;* Sans., **aftra,** (Cfr., ἀστήρ), *sky;* **dyu, ra′dɟ, sur,** *to shine;* **divaˢ,** *day;* **div,** *sky;* **dyauˢ,** *the bright heaven,* or *aether;* (whence Σεύς, θεός, *deus, dies,* **deva**);† **raviˢ, sunuˢ, syu′naˢ, su′ryaˢ,** *sun;* Chin., jih, yang, *sun, day, light;* suy, *name of one of the nine heavens, shining and glossy, a burning-glass, the planet Jupiter;* tăng, *a light raised high;* tung, *sunrise;* lang, *lofty, bright and clear;* lung, *lofty, conspicuous;* Dak., aŋ, yaŋ, or źaŋ, *to shine* or *emit rays* (the Dakota, like the Chinese, has no *r* sound); aŋpe, *day, space;* iźaŋźaŋ, oźaŋźaŋ, iyoyaŋpa, *or* iyoźaŋźaŋ, *light;* iyaŋpa, *to push out.*

37. MOON.—1, 2, 5, 8, 9, muesi; 3, moi; 4, lubbo; 8, molungo; 6, inyanga; 9, tangua; 10, tunga; 11, 12, boulan; 13, 14, 15, marama; 11, vola; 14, vala, hual. Cfr., Yor., mó, *to shine;* os′ukpa, *moon;* (kpa, *to break, to cut in two;* wa, wari, *to divide, to share*); Egyp., mau, *to gleam, splendor, intellect* (Yor., mò, *to know*); Dak., mac′a, *the red of the morning, aurora;* wega, *broken;* wi, *sun, moon, month;* Sans., **vi,** *away, apart;* Chin., yue, *to separate, moon;*‡ me *or* mei, *to open, to spread out;* wei, *light.* For the roots *ra, la, lung, tang, yang,* v. SUN.

38. HEAVEN or SKY.—11, langhits; 12, languit; 13, lani, langui, rahi, rani, rangui; 14, lang, langi; 15, rang, rohotang. v. SUN.

39. EARTH or LAND.—11, 12, 15, tana; 12, benua; 13, wenoua, fonoua; 13, 14, penu, panua, vanua. Cfr., Yor., ta, tè, *to spread, to push forward;* tara, *gravel;* Egyp., ta, *the world;* Dak., taŋ, *to touch;* Chin., ta, *large, extensive;* tă, *to touch, to build up, earth heaped up;* tan, pan, fan, *to extend, wide, thin, great, bank, to feel with the hand;* tang, *large, to extend;* te, too, *earth;* Sans., **tan,** *to spread, to extend;* **tanuˢ,** *thin;* **ti′ra,** *a shore;* **dhara′,** *earth;*

* The word amo is differently accented, to express the two meanings, but I think there can be little doubt of their common etymology. I have not thought it necessary to mark the distinction between the open and close Yoruba vowels.

† "Epicharmus (470, B. C., in Megara), taught that Zeus was nothing but the air, and other gods but names of the powers of nature." Max Müller, *Lectures on the Science of Language,* p. 105. See also ibid. p. 21.

‡ Do the Yor. *wari,* Dak. *wi,* Chin., *yuĕ, me, wei,* show that these nations, like the Aryans, named the moon "the measurer?" M and w are often interchanged in Chinese. See Müller, op. cit., p. 16.

Lat., pando, tango, tendo, tenuis, terra; Yor., wa, wò, ro, *to dig, to excavate, to till;* wé, *to grind, to mash;* ro, *to be soft;* orò, *clay;* eru, *ashes;* erukpe (Dak., wakpukpa), *earth, dust;* Chin., wa, *bricks or tiles made of earth, a mud or clay house, a dirty puddle;* Sans., r̥, *to go;* the probable primitive of the Indo-Germanic root ar, in ἀρ-οῦν, *ar-are, ear, e-arth,* &c. [See Müller, p. 252, sqq.]

40. WATER.—1, 5, madshi; 2, madzi; 3, maudzi; 6, maasi; 7, meetzi; 8, maschi; 9, maza, muza; 11, ranu, ranoa; 12, aier, aer; 13, 14, 15, wai, vai; 15, nui, nuai. Cfr., Yor., omi, odo, *water;* ro, d o, *to drip* or *drop* as water; ro, *to rain;* riŋ, we, *to wash, wet;* re, *to soak;* Chin., lan, *to overflow, inundation;* me, ne, *the appearance of water flowing;* wa, *clear water;* wan, *to cleanse with water, water whirling in an eddy;* we, *a slight shower;* wei, *a great accumulation of water, water agitated;* shwuy, *water;* yu, *rain;* Egyp., mah, muau, nm, *water;* rm, *to weep;* rz, *to wash, pure;* ba-ba, *to flow;* bah, *to inundate;* Dak., mini, *water;* mde (=mre, Lat., *mare*), *a lake;* źaźa, *to wash;* we, *blood;* wakpa, *a stream of water;* Sans., u,d, *to moisten;* uda,, *moist;* va´,r, *to go;* vari, *water;* Gr., ὕδωρ, μαδάω, βαινω, ἀήρ; Lat., unda, uvidus, madeo, ros, rigo; Ger., regen, rein; Eng., rain, rinse, water, wet.

41. RAIN.—11, oran; 12, oudjan; 13, 14, 15, oua, or ua; 13, uas. v. WATER.

42. SEA.—11, ran, ransa, taik; 12, last, tassek; 13, taï, kaï, mouana taï; 14, gami, vaitni, sas; 15, tai, tasi, ntiop. Cfr., Yor., ga, *to be tall;* agbami, okuŋ, *the ocean* (gba, *to collect together;* koŋ, *to be full*); tere, *a wave of the sea;* ta, té, *to spread out;* to, *large;* Egyp., ht, *the sea;* Chin., lang, *great, deep, a wave;* hae, *the sea;* tae, *broad and extensive, waters flowing to excess;* kung, *great, wide, to bind;* mwan, *full, excessive quantity of water;* Sans., sagaraˢ, samudaˢ, *the sea;* Gr., ὠκεανός. v. WATER.

43. MOUNTAIN.—11, oohits; 12, ooakit; 13, maounga pouke; 15, ora; 13, maounga, maouna, mona; 14, maunga, mami. Cfr., Chin., mwan, man, moon, *long, extensive, to cover, or be covered with earth;* mang, mung, *great;* wei, *a mountainous appearance;* Egyp., hu, *a hill* (Ger., hügel); Yor., giga, *height;* gele, *to be elevated;* gori, *to ascend;* gere-gere, *slope,* or *brow of a hill;* wu, *to swell, to increase;* ori, *head, top;* ke, *to extend;* oke, *mountain;* Gr., ὄρος, γίγας; Lat., mons; Sans, mahi´draˢ, girisˢ.

44. LIGHT.—11, herek herek; 12, tarang djaia; 13, mama, malamalama; 14, sararama; 15, ao. Cfr., Yor., mana mana, *lightning;* maraŋ maraŋ, *in a bright, dazzling manner;* Gr., ἥλιος; Lat, mane, matutinus, aurora. v. SUN.

45. LIGHTNING.—11, helet; 13, wira, wila, wiba. Cfr., Yor., wele, *wavingly;* were, *to be quick-motioned;* wiri wiri, *quickly, twilight;* Gr., ἥλιος; Chin., wei, *tortuous, light, splendor;* Sans., vegaˢ, tvara´, *quickness;* vidyut, *lightning.*

46. Dr. Prichard closes his comparative lists with the following remarks: "It will be perceived from the examination of this vocabulary, that many of the languages spoken by the black races contain numerous words which resemble the Polynesian. Whether these

words have been adopted by the Papua tribes in their accidental intercourse with Polynesians, or belong to both races from primeval times, is a problem yet to be solved. The former opinion seems at first the more probable, but it is doubted much by those who have most carefully studied the languages of these nations."*

47. The belief in adoption might be plausibly defended, if the words were such as are rarely used, or if they were mere synonymes. But as they denote some of the most common objects, such as must be among the earliest named in any language, and as their analogues are found not only among the islanders of the Pacific, but also among the Chinese and Indo-European tribes of the continent, there can be but little, if any, ground for a reasonable doubt, that the similar words are parts of a very ancient inheritance from a common ancestor.

48. The field of etymological resemblance in Yoruba, is not confined either to the radicals or to the derivatives, but it presents even to the superficial observer, a great number of connected analogues, some of which are radical, while others are derivative. Some of the coincidences, especially with Latin and Greek words, are so striking, that I was inclined to believe the words might have been introduced by merchants and slave-traders, until their evident derivation from well-known Yoruba roots, satisfied me that they were indigenous. The following list will illustrate the character of these coincidences:

abetele, a begging beforehand; Ger., bitteln.
abi, having. Lat., habeo.
agoŋ, strife. Gr., ἀγών.
ake, an axe.
ake, a large she-goat. Gr., αἴξ.
akoŋ, beads made of shells. Gr., κόγχη.
akuko, a cock. Sans., cucuta.
amona, a guide. Lat., moneo.
ataba, a dove. Ger., taube.
ati, and; adi, after all. Gr., ἔτι.
auro, morning. Lat., Aurora, eurus.
awari, search. Eng., aware.
bale, or basile, landlord. Gr., βασιλε-ύς.
bata, a small box. Eg., baita. Heb., בת.
beru, to fear. Lat., vereor; Sans., bhirus.
bi, to beget, to breed. Gr., βίος.
da, to give. Lat., dare.
dile, to be *dilatory*. Eng., delay.
duro, to stay. Lat., duro.
emi, I, me. Gr., ἐμέ.
eni, one. Gr., ἕν. Ger., ein.
ekaŋ, once. Sans., ecas.
eni, a person. Gr., ἕντοι.
es'iŋ, a horse. Lat., asinus.
fere, almost. Lat., fere.
fiŋ, to terminate. Lat., finis.
fiŋ, to be fine or nice. Fr., fin.
fu, to grow, as a plant. Gr., φύω.
giga, height. Gr., γίγας.
i, he. Lat., is.
ibe, there; ibi, here. Lat., ibi.
idaro, *dross* of iron, cinders.
igoŋ, angle. Gr., γωνία.
ihiŋ, hither. Ger., hin; Eng., hence.
iriŋ, *iron*.
iwora, greediness. Lat., voro.

* P. 666. For further Polynesian vocabularies, see Humboldt's "Kawi-Sprache."

kata-kata, to *scatter*.
ke, to cherish. Lat., carus.
kiri, about. Lat., circum.
kole, to make hills or beds of earth. Lat., colo, collis.
kuru, to be short. Lat., curtus.
ni, in. Sans., ni.
niha, nikusa, near. Sans., nicaſa´.
ore, a watch-tower. Gr., *ὁράω*.
oro, erect position. Lat., orior; Eg., ar.
oro, wealth. Lat., aurum.
oruŋ, sky. Gr., *οὐρανός*.
re, *red*.
rudi, to bud. Lat., rudimentum.
saŋ, to be in health. Lat., sanus.
si, to be. Lat., esse.
s'aferi, to seek. Gr., *σώφρων*.
s'eke-s'eke, *shackles*.
s'okaŋ, to agree. Lat., socius.
tedo, to be patient. Lat., tedium.
tere, to be slender. Lat., teres.
toto, to be whole. Lat., totus.
tu, to spit. Gr., *πτύω*.
wura, gold. Lat., aurum.

49. Evidence of the antiquity of many of these forms, and of their derivation from roots that are a common inheritance of the Aryan, Shemitic, and Turanian languages, may be found in the following

Comparative Vocabulary.

50. Abetele.—A, is a formative prefix, attached to verbs to denote the actor, the recipient of an action, the action itself, or the abstract quality implied in the verb; be, a verb, signifying *to beg, to entreat, to be imprudent, to jump;* tele, *adv., previously*, probably derived from te, *to spread out, to push forward*, and le, *to exceed*. If Skinner's derivation of beg from bag, which Wedgewood adopts, is correct, the analogy may be still further extended in Yoruba, by the words ba, *to bend, to plait, to meet*,—bo, *to cover*,—bo, *to insert*,—abo, *a bag, a bundle*,—laba, *a leathern bag*. Cfr. Lat., peto; Sans., bhicſ; Heb., בקש.*

51. Abi.—A formative, and bi. Among the many forms of the Yoruba substantive verb, we find mbe, which "denotes existence, *absolutely*," and gbe, *to abide*, which "takes the place of mbe in the imperative and subjunctive." Abi is defined as *a prefix;* implying *being in a state of, having, an existence, a being*. From these definitions it would appear that bi had once the simple meaning of our English verb be, as well as its present causative meanings, *to affect, to generate*.† The Latin *est mihi*, = *habeo*, the use of the verbs to be and to have, in the formation of preterites, in many languages, and the kindred forms

* In these comparisons, I pay no regard to the Yoruba accents, which I am satisfied were invented merely to denote different modifications of the primitive radical meanings. The comparative words are intended merely as suggestive, without implying that they are necessarily cognate.

† Wedgewood compares be, with A. S. *beon;* Ga., *beo*, alive; Ir., *bioth*, life, the world; Gr., *βίος*; and says, "The Irish verb substantive is formed from a root *bi*, the W. from a root *ba*, *bu*." Bowen's Gram., p. 17, says that Yor., bi, *if*, is "probably from the obsolete verb bi, *to be*, which is still retained in composition, e. g., abi, *the state of existence*."

of the future, to which reference was made in paragraph 25, page 41, render the radical affinity of abi and habeo very probable. Cfr. Eg., pe, pu, *the, to be;* Lat., capio; Heb., בָּה.

52. Agoŋ.—A formative, and goŋ. Kindred forms are found in goŋ-go, *to be sharp;* go, *to be long and slender;* goŋ-goŋ, *to be large or prominent;* guŋ, *to strike against, pound, stab, pierce.* Cfr. Sans., han; Lat., con-tra; Ger., gegen; Gr., *γωνία.*

53. Ake.—A, *that which*, and ke, *to cut.* Cfr. Sans., agri, *an edge;* Gr., *ἀχή, ἀξίνη;* Lat., *ascia, acies;* Shyenne, hoak, *an axe;* Dakota, ksa, *to separate;* Blackfoot, koksakin, *axe* (Chin., kin, *metal, an axe*).

54. Ake.—A, *that which*, and ke, *to cherish.* Ke may be a modification of the older form ka, which signifies *around, to fold.* Cfr. Lat., carus; E., caress.

55. Akoŋ, or Akuŋ.—"That which hums." Formative a and koŋ, or kuŋ, *to hum, to murmur.* The word is probably exotic, or it would be used for the shell itself, as well as for beads that are made of shell, but it suggests a very plausible etymology for *κόγχη.* The probability of a radical connection is strengthened by the fact that the Yoruba word for knee is ékuŋ, while the knee-pan (*κόγχη*) is translated by dźaŋgboro. Bo signifies *to cover;* boro, *very near*, and dźaŋg seems akin to Sans. ǰanuˢ; Gr., *γόνυ*; Lat., genu. In Chin., kăng [Morrison, No. 5121] denotes *a ringing noise;* kung [M., 6583], *to lay hold of with the hand,* to grasp round, to bundle up;* kŏ [M., 6451–68] *to surround, a shell;* kang [De Guignes, 12,781], "*magna couchylia.*"

These resemblances are suggestive of an onomatopoetic gradation of ideas, based on the murmur of the hollow shell, which may be represented by the English words *call, conch, curved.* A similar gradation is perhaps traceable in the Yoruba words ko, *to call;* kara, *loudly;* karawoŋ, *a conch-shell;* (woŋ, *to weave;* wo, *to be hollow, to enter into;* awoŋ, a tortoise); kakara, *a muscle-shell;* ka, *to fold, to roll;* kpe, *to call;* kpe-kpe, *a shell.*

56. Akuko.—Ako, *the male of beasts;* ko, *to call, crow, shout.* "The male crower."†

57. Amona.—Ami, *a spy, a sign;* ona, *a road*,—or a, *one who*, mo, *knows*, ona, *the road.* The word ami, *one who sees*, or *that which is seen*, points to an obsolete Yoruban root mi, *to see*, for which an equivalent is found in Lat. miror. The subordinate radical in miror, may be cognate with ra or ri in Eg., ra, *the sun;* iri, *the eye;* Yor., ri, *to see;* iri, *sight;* Gr., *ὁράω.*

58. Ataba, or Adaba.—Ata, *the ridge of a house*, ba, *to alight, to sit.* "The roof-sitter." The primitive meaning of ata appears to be "that which is spread out," from ta, or te, *to spread.* Wedgewood associates dove with dive, and refers to the curious resemblances between *columba* and *κολυμβᾶν.* If the etymon of *κολυμβάω* were known, this single word

* Cfr. Sans. cangulaˢ, *hand.*

† In Dakota, the cock is aŋpao-hotoŋna mdoka, "the male dawn-crower."

would perhaps furnish strong evidence in favor of radical verbal analysis. The ideas of height and depth are so nearly allied, that both are expressed, in some languages, by the same word, and *columba*, or *colum(en)–ba*, "the column-sitter," might be naturally associated with *κολυμ-βᾶν*, "to go from a column," *to leap, to dive.*

59. ATI, or ADI.—A, *that which;* di or de (*δέω*), *to bind;* ti, *to tie, to bind, and.* Cfr. Lat., et, ad; Eg., at, *to build;* ati, *a lintel;* Eng., at. Ti also signifies *to support*, and igi, *wood, stalk.* Cfr. Fr., *tige.**

60. AURO, ORO, or OWURO.—A, formative, and wu, *to please;* awu, *that which pleases*, or o, *it, that*, and ro, *to turn from a course or position, to bend or break at the edge, to gush out;* ru, *to rise, spring up, break out.* "The pleasant break" of day. The ideas of redness and brilliancy are naturally associated with the dawn, and traces of this association may be found in Yor., roki-roki, *brightly;* roro, *with a fine red color;* re, *red;* oro, *wealth*, and wura, *gold.* Cfr. Eg., aui, *to glorify;* auu, *splendor;* ra, *sun;* auru, *a bean* (Yor., awudźe, *red beans;* dźe, *to eat*); Sans., **ra'dɟ, rutſ,** *to shine;* **ra.dɟ,** *to dye, to color;* **racta, rohita,** *red;* **arunaˢ,** *dawn;* Gr., *ἐρυθρός, ῥόδον;* Lat., ruber, roseus, radius, aurum; Chin., tsaou, *morning.*

61. AWARI.—A, formative; wa, *where? to seek, to share;* ri, *to see, to find.* Cfr. A. S., warian; It., guardare; Sans., **vr,** *to select.*

62. AYE.—Space, opportunity, time, alive; AYIDA, change, cycle of time; LAI, LAI-LAI, ever, forever, oldness. A, formative, ye, *to live;* yi, *to revolve, to move.* Cfr. Sans., **ayuſ, vayaˢ,** *age;* **avyaya,** *eternal.* Gr., *αἰών, ἀεί,* Lat., ævum, ætas, æternus; Goth., aivs; Chin., laou, *old.*

Wedgewood says, in discussing the two English meanings of aye, "The passage from the notion of continuance, endurance, to that of asseveration, may be exemplified by the use of the G. *je, ja; je und je*, for ever and ever; *von je her*, from all time; *wer hat es je gesehen*, who has ever seen it? *Das ist je wahr*, that is certainly true; *es ist je nicht recht*, it is certainly not right. In the same way the Italian *gia; non gia*, certainly not. From this use of the word to imply the unbroken and universal application of a proposition, it became adopted to stand by itself as an affirmative answer, equivalent to certainly, even so, just so. In like manner the Lat., *etiam* [et-jam] had the force of certainly, yes indeed, yes. . . . . In *yes*, we have the remains of an affix, *se* or *si*, which in A. S. was added to the negative, giving *nese*, no, as well as *jese*, yes."

A difference similar to that between German *je* and *ja*, is observable in Yor. ye, *to live*,

* Marsh (under At, p. 54), speaking of the frequent synonymous use in Icelandic, of a, at, and i, as nearly equivalent to *an* in the Old Saxon of the Heliand, and *on* in many of the Anglo-Saxon writers, suspects that *a* may be probably another form of *at*. In Yoruba we find all the vowels used as demonstrative roots, and they may very easily and naturally have been employed to denote relative position.

and ya, *to be*, *to be sprightly*. From Yor., ya, *to be;* si, *to be*, and n, *no*, may readily be derived, *ya-si* = *jese*, it is is, and *n-si* = *nese*, it not is. (Cfr. Ital., si.) Ya, in Yor., also has the meanings, *to hasten*, *to be easy of performance*, *to select an image to worship*, which seems to ally it to the Dakota ya, *to proceed*, *to make*, *to regard as*, *to resemble*.

63. BALE, from oba or baba, *father*, *master*, *king*, and ile, *house*. From ile, *ground*, *earth*, is formed in a similar manner, BALE, a governor. The Yoruba preposition si, *of*, which has been dropped, appears to have been retained in the Gr. βα-σι-λε-ύς, "he-who-is-master-of-the-land." The preposition is often omitted in Yoruba, the relation being implied, as in Chinese, by the collocation of the words. Thus oba ile = oba si ile, and ile oba, *a kingdom* = ile si oba, *the land of the master*. I cannot believe that this curious coincidence is merely accidental. The chances against it, assuming the chance of a single coincident syllable to be as great as $\frac{1}{100}$ are at least 100,000,000 to 1.

64. BATA.—Ba, *to bend*, *to fit*, *to meet*, &c.; bo, *to cover;* abo, *a bag*, *bundle*, *covert;* ta (Chin. te), *to spread*, *to kick*, &c. Bata has the several meanings of *hide*, *leather*, *shoe*, *sandal*, *hoof*, *small box*, *a kind of drum*. Cfr. Sans., petica′, *a box;* Gr., βύω, κίβυσις, κιβωτός; Sp., bota, botila, *a leather bag for wine*, *a butt* or *cask;* botella, *a bottle;* It., botte, bottiglia; Fr., botte, boute, bouteille, bouton; Eng., boot, butt, bottle, button, bud.

65. Marsh has the following note, under "Bottle," in Wedgewood's Dictionary, p. 115: "Gazi, quoting Hesychius, says that the Greek πυτίνη, the name of a flask or jar covered with wicker-work or plaited thongs, was pronounced βυτίνη by the people of Tarentum in Magna Græcia, and that this latter form was gradually corrupted into βυτίων, βουτίον, and βουττίον, whence probably the Italian *botte* and its diminutive *bottiglia*. The glossary of Sophocles gives several other closely allied forms, and this must be regarded as a more probable etymology than that proposed by Wedgewood, though it leaves the primary source of πυτίνη unexplained." The affinity of these words can hardly be questioned, but there may be some doubt as to which is the earliest form. The old idea that Latin was derived from Greek, is now generally exploded, and as many Latin words bear internal evidence of greater antiquity than the corresponding Greek terms, it is not improbable that an old Umbrian *bata*, should become successively βοτί, βουτίον, and βυτίνη, before it was transferred to Greece, and the β be subsequently corrupted into a π. This hypothesis at least supplies Marsh's desideratum, by giving an explanation of the primary source of πωτίνη,—an explanation which may be made still more complete by adding to bata the Yoruba root na, *to stretch*, *to extend*, making ba-ta-na = πυ τι-νη. From the connection between Moo, βου-ς, bo, ba, Mr. Wedgewood might perhaps derive some confirmation of his onomatopoetic views.

There is a curious connection between Yor. laba, *a leather bag*, *satchel* (la,* *to split*, ba, *to bend*, &c.), and laba mole, *robbers*, *kidnappers* (mole, *to conspire;* whence laba mole, *con-*

* Chin. leĕ, M. 7073.

spirators to seize the *leather bags* of travellers). Can this laba mole, which appears to have denoted one of the earliest kinds of seizure, have any affinity to the root of λαμβάνω, λαβ?

66. BERU.—Ba, *to come in contact with, to find;* eru, *fear, awe, terribleness.* Eru is compounded of e = a, formative, and ru, *to be agitated.*

67. BI.—Cfr. Sans. pi (Chin., fe, pe), *to fecundate, to grow fat;* vi′, *to conceive, to bear;* Dak., be, *to hatch.*

68. DAKE, *to be silent, to cease.* Cfr., Lat., taceo, cesso? Da is sometimes used alone in the sense of *to cease.* The effect of the ke appears to be merely intensive. It may be allied with ke (Eg., ki), *to cut;* KE-KE-KE, *littleness;* ke-ke, *profound silence;* ki, *not.* Cfr. Ger., klein.

69. DE, DI, TI, *to bind, tie, shackle.* v. § 59.

70. DI, *to require, to be deficient, from.* Cfr. Gr., δέω; Lat., de.

71. DILE.—Di, *to be deficient, from;* le, *to be strong, to lay upon;* le, *to lay one thing lightly on another, lazy* (ile, *the ground* = "that which is laid level or flat;" be-le, fe-le, *to be flat*). Delay and dilatory are undoubtedly derived from the Lat. dilatum; and latus, in its several meanings of *brought, broad, side*, must have been derived from roots of kindred meaning with Yor. le, or lĕ, and te, which also signifies *to lay, to spread out.* The probability of a common origin as well as kindred meaning, is increased by the fact that Yor. AFARA, *slowness, dilatoriness*, presents a strong radical resemblance with Lat. fero. For afara = a, *the state of;* fa, *dragging;* ra, *struggling.* The second root of the Latin verb, as well as the first and third, may also be traced to the Yor. auxiliary ti, *have*, HAS, *had*, and ile; for in Yoruba, in order "to avoid an inconvenient hiatus, it is customary in speaking to drop either the final vowel of the verb, or the initial one of the noun which follows it. . . . In a few cases neither vowel is dropped, but the two are exchanged for u."* Ti ile, "I have grounded, or laid," might, therefore, be euphonically contracted either into tile or tule.

The germinal significance of the three roots of fero, may therefore be, 1, fer, *I drag with difficulty;* 2, tul, *I have laid down* my load, after bringing it; 3, lat, *laid down*, after being brought. If there had been any historical consanguinity between the Romans and Yorubas, this etymology would doubtless be received without hesitation. Is it not equally credible, notwithstanding the want of historical evidence, in view of the immense probabilities against the fortuitous occurrence of such a connected series of coincidences?† And

* Bowen, pp. 6, 7. For another interesting instance, illustrative of both modes of contraction, see the discussion of Fere, *infra*, § 91.

† With the same moderate assumption as in § 63, the adverse chances would be at least $(100)^6$, or 1,000,000,000,-000 to 1. The chances against the combined coincidences of βασι-λεύς, fer–, tul–, lat–, would, therefore, be at least $(100)^{10}$, or 100,000,000,000,000,000,000 to 1.

if its credibility be admitted, is it not evident that the Yoruba must be older than any of the Indo-European languages? Cfr. Chin., le, *to arrange, to descend to, to fix, to exert one's strength, laws;* te, *earth, low, level;* Sans., prath, *to be extended;* Gr., πλατύς, λέγω; Lat., latus, lego, lex; Fr., plat; Eng., flat, lay, broad. The two principal meanings of λέγω, are represented by Yor. le, *to lay*, and li, *to say*.

72. De, *to cover*. Du, *to be black*. Cfr. A. S.. deorc, *dark;* Scotch, dhu. See Wedgewood's discussion of Dun, for some remarks on the connection between the ideas of covering and darkness.

73. Duro, from da, *to become*, iro, *standing*. The a and i are contracted into u, by the euphonic rule quoted under § 71. Wedgewood quotes as analogous, δηρός, durus, and Turk. durmak, *to continue, stay, endure*. The application of the two rules of assimilation, would produce both forms, δηρο and duro, from da iro. The Yor. duro does not appear to be used in the sense of Lat. durus, but dilu, *to congeal*, may perhaps be its equivalent, for di signifies *to be, become, be changed*, and as l and r are mutually interchangeable, *lu* = *ru* or *ro*. If for the di in dilu, we substitute its equivalent dźe, *to be*, we obtain dźelu, which is curiously coincident with Sans. ḍʒal, *to be cold;* Lat. gelu; Fr., geler; Eng., chill, jelly. Even without any commutation of letters we may obtain the French form, for ele, *hardness* (from e, *that which*, le, *is hard*), added to dźe, would make dźele, *to become hard* = geler.

74. E, or ai (a, *that which*, i, *not*), "a prefix attached to verbs to form nouns of a negative meaning. . . . Roots with this prefix are also used imperatively; as, aiwi, *do not speak, keep silence!*"* Other Yoruba negative forms, are mah, n, o, o. Cfr. Gr., α, *privative*, μή, οὐ; Lat., in–, ne, non; Eng., no.

75. Emi, or Mi.—These forms are used indiscriminately for I, my, and me. The contracted form is rarely used in the nominative, except in repeating something that has been said. But "as the objective pronouns are generally governed by a preceding word to which they are closely attached in pronunciation, the contracted forms are, for the most part, made by eliding the initial vowel of the pronoun, so that it may be more closely joined to the governing word. . . . . The full or primary forms are employed as possessives only when the relation of possession is expressed by the preposition ti, *of*."†

There are three other forms of the nominative,—the euphonic mo, mŏ, and the future, or negative ŋ; and two forms for each case of the plural, the full form, awa, for all the cases, and the contracted forms, a for the nominative, and wa for the possessive and objective. The form ŋ "appears to be a modification of emi. The manner in which it is formed is seen in the subjunctive phrase, ki emi ri, *that I see*, which is frequently contracted to ki em' ri, and ki 'm 'ri; and is still more frequently pronounced ki ŋ ri."‡

We are thus enabled to trace a pretty satisfactory etymological connection between Chin.

* Bowen, p. 13. † Id., p. 21. ‡ Id., p. 19.

go or ngo, no, and wo; Sans , aha„ ma′, me, a′wa′„ nau, vaya„ asmat,* naˢ, &c.; Gr., ἐγώ, ἐμ-, μ-νω-, ἡμ-; Lat., ego, m-, nos; Ger. ich, mir, wir, uns; Eng., I, my, me, we, us; Dak., mis′, mi, ma, wa, we, uŋ, or uŋk. It will be noticed that all these languages, except the Dakota, base their nominative singular on the form which is usually employed in Yoruba only for future or negative propositions. But ŋ and m are both used in connection with verbs as particles of continuance, in which office Bowen regards them as probably a contraction of ni, *to be.* Ngo, go, ego, emi, mi, ich, I, may, therefore, be the simplest affirmations of personality, and universal humanity may thus be bearing constant, though unconscious testimony to the truth of Des Cartes' celebrated maxim, "Cogito, ergo sum."

The Greek alone retains, both in the singular and plural, the full form of the root em-, together with the contracted m- in the oblique cases of the singular. Sanscrit corresponds more closely with Yoruba in the dual and plural, having all the forms, awa, wa, and a, but it also retains in those numbers the nau and naˢ, which ally it so intimately to Greek and Latin. The elision of the initial vowel in the oblique cases of emi, which is general in Yoruba, becomes universal in Sanscrit, Latin, German, and English. The two latter languages agree with Sanscrit, in retaining the Yoruba plural wa, as well as traces of the pluralized ŋ-s. Dakota uses mi in all cases of the singular of the separate, and in the possessive and objective singular of the incorporated pronouns; wa and we in the nominative singular incorporated; ma, in the possessive and objective singular incorporated; uŋ, in all cases of the dual and plural.

76. Eni.—E ni, *that which is.*

77. Ere, *an imprecation, a question;* ara, *an outh;* ero, *a relation or telling;* ro, *to tell, to relate;* Cfr. Eg. r; Copt., ro, *mouth;* Gr., ἐρέω.

78. Ere, *gain, interest, earnings, a crop;* eru, *ashes;* ekuru, *dust;* erukpe, *dust, earth;* ro, *to till;* ru, *to mingle;* aro, *that which is tilled.* In these words we find the traces of that ancient root AR (a re, *that which goes*), from which the names of the Aryan race, and of the earth itself, are derived. Prof. Max Müller has given an interesting discussion of the root in its secondary meaning of *to plough*, together with some of its most important derivations, quoting Pott's remark that, "AR might be traced back to the Sanscrit root *ri*, to go."† The corresponding Yoruba word, re, not only retains this meaning, but it also has the signification *to be good*, which allies it still more closely to the Sanscrit *A′rya.* In ro, *to fabricate from any raw material*, we have the secondary meaning which is retained in Lat. *ars*, and Ger. *arbeit.* The association of the tilled ground with the idea of *pounding, breaking*, is so natural, that roŋ, ruŋ, *to chew*, ruŋ, *to break to pieces*, and lo, *to grind*, may very probably be correlated. Their analogues are found in Chin. luh, *dregs*, loo, *mixed*, lă, *to break*,

* The radical significance of the plural formative s, may be traced in Yor. si, *to, and;* s′a, su, *to collect;* s′e, *greatly.* "Motion *from* is invariably expressed by ti, and motion *to* by si."—*Bowen*, p. 52.

† Lecture on Languages, p. 252, sqq.

to destroy, lan, *to break*, le, lung, mo, mo-le, mo-lung, *to grind* (mŏ, *dust;* Yor., mo, *to adhere, to build or form of clay;* Dak., maka, *ground, earth*); Sans., mrd, *to grind;* mala, *dirt, sediment;* rudɟ, *to break.* Gr., *ῥάχος, ῥηγν-, μύλη;* Lat., frang-, mola, mollis; Goth., brikan, malan; Dak., mdu (= mru or mlu, as the Dakotas have no l or r sound), *fine, pulverized,* mdeća (= brec'a) *broken;* Crow, ara'tſic, *agriculture;* Pawnee, ara'nu, *earth.*

79. Eriŋ, *elephant.* E riŋ, *that which is heavy.* Cfr. Gr., *ῥώ?*

80. Efufu, *wind, breeze, air.* Cfr. Chin., fung.

81. Egbera, *equality;* iro, *an equal;* ogba, *equality, a balance, an equal;* gbe, *to take up, to raise;* gbe . . . ha, ro, so, *to hang up, to suspend.* Cfr. Chin., kwa, *to hang up, to suspend;* Lat., *æqualis;* (libra, Sans, li, *equality*, lab, *to hang*); Gr., *ῥοπή, ἴσος;* Sans., sama, *equal.* If any evidence is needed to prove the affinity of gba and kwa, we find the idea of fluctuation (like a balance), represented in Yoruba by b, m, and w. E. g , bo, *to shake hands;* gba, *to float about;* agbami, *the open sea* (Cfr. aqua, mare); mi, *to shake, to swallow* (Cfr. Chin., me; Dak., mini, *water*); ma, *to stroll about* (in made-koso, *a strolling beggar who tells news for a living* = ma deke o so, *stroller lie-inventing who talks;* Cfr. mendax, mendico, mentior); wa, *to tremble;* wara, *a shower, milk* (Cfr. Goth., vato, *water;* Sans., va, *to go, to blow;* va'ri, *water;* tſal, *to tremble;* dɟala, *water*); wariri, *to tremble greatly;* wele, *wavingly;* we, *to twist* (weben, weave, wave); we, *to wash, to swim.* That the word Mind, itself, as that which *dis*-cerns, weighs, de-*liber**-ates, and is *intel*-ligent, has a kindred origin, appears probable from Yor, mi, *to breathe;* mo, *to know, to understand;* mero, mete, *to reflect, to consider, to meditate;* ma, *truly;* mamodźa, *to guess* (= to endeavor to know truly. Cfr. Lat., memoro = ma, *truly*, mo, *to know*, ro, *to stir, excite, intend;* Eg., ma, *truth;* Gr., *μάν, μέν, μήν*); won, *to measure, to weigh;* Sans., ma, *to measure;* manas, *mind.* For corresponding vowel changes Cfr. Sans., ma's, Gr. *μήνη*, A. S. mona, Ger. mond; *moon.*

82. Ehiŋ, *the back, hinder part.* Cfr., Chin., heang, *the back part of the head or neck, that which rests on the pillow, the strings which tie a cap behind;* Ger., hin, hinter. Wedgewood institutes a comparison between behind and the Finnish hänta, *the tail.* This is evidently a compound word, the first syllable compounding to the hin in hinter, and the second may probably be the old root ta, tan, taŋ, *to extend, to stretch out*, which is found in nearly all languages. Cfr. Yor., siŋ, *before*, te, *to push forward, to spread out.* Dak., siŋte, *tail.* The dental s would be a natural sound for the expression of what is before, and h, which is formed far back in the head, for what is behind, and in composition with ni or ŋ, *to be*, these consonants would make siŋ and hiŋ.

83. Ekaŋ.—Ka, ko, *to gather, to collect;* eka, eko, *that which collects;* kaŋ, okaŋ, ako, akŏ, *one.* See Oŋ, § 131.

* Liber-ty, is the form of balancing or vi-*bra*-ting between two courses of action.

84. El, Al.—Prefixes, denoting *the actor, owner.* E or a, *he who;* i, *he, she, it;* li, *has, is.* Cfr. Arab., *al;* Lat., *ille.* The three demonstrative roots, e, a, and i, are all retained in the declension of Lat. *is.*

85. Eni, *a person, one, any.* Cfr. A. S., an-ig. Eng., an-y. v. Eni, § 76, Oŋ, § 131.

86. Eraŋ, *beast, goat, sheep.* From e, *that which,* and raŋ, *to wound.* Cfr. ro, *to strike;* Eng., ram; Lat., aries?

87. Ese, *a foot, track, course, row, order.* Cfr. Lat., secundum, secundus, series, sequor. Gba (= qua, v. discussion of § 81), which has the meanings *to collect together, to assist,* and ri, *to be,* with ese, give ese qua, and ese ri, which coincide closely with the Latin analogues. Sill, and sole, may be allied with the same root, with the termination le, *to lay upon,* or le, *down, on the ground.*

88. Es'iŋ.—From e, *that which,* s'iŋ, *to run precipitately.* Cfr. asa, *a runner;* asaloh, *one who runs away;* aso, *a leaper;* Sans., aɕvaꞃ, *a horse,* ɕal, ɕval, *to run;* Lat., asinus, salio; Goth., asilus; A. S., asal; Ger., esel.

89. Eto, Oto, *truth.* Cfr. Gr., ἔτυμος = e to ma si, *that which true really is.*

90. Eyi, e, he, heyi, *yes.* See Aye, § 62.

91. Fere.—Fe and fi appear to have a common origin; fe, *to blow;* (fe no, *to fan, to blow off;* be, *to cool by fanning*); fi, *to swing, vibrate, incline to one side;* hence (by the association of ideas that renders "inclination" a synonyme for "desire") fe, *to love, wish, desire;* fiti, *to lean against;* fi ehiŋti, or fehiŋti, *to lean on, to trust in* (Cfr. Lat., fides, in both its meanings of *trust,* and a *string;* Eng., *fiddle*). From fe, *to love,* are formed the noun ife, *love,* which in its turn becomes the root of lufe = li ife, *to have love,* and olufe, *a lover,* or *one beloved,* = o li ife, *he has love.* By different juxtapositions of these roots, we may readily account for the formation of Chin. fe, *to do a kindness to;* Sans., pri', *to love;* lubh, *to desire;* Gr., φιλέω, πρᾶος, λίπτω; Lat., libet, lubet; Goth., friond, liubs; A. S., leof, lufian, friond; Ger., lieben, freuen, freund. From fi, *to be flexible,* are derived fi, *to place, put, apply to a purpose, to make* (Lat., *fio*); fi . . ro, *to twist;* fi le, *to make pliable;* fi lo, *to make twisted;* fiŋ-riŋ, *a thread.* Cfr. Lat., filum, flecto; Fr., filer.

92. Fiŋ.—Probably from fi, *to make;* whence fi ni or fi ŋ = *to be made, to terminate, to be perfected, to be fine.* Cfr. Lat., finis; Ger., fein. The English fine = *thin, slender, delicate,* retains the still older idea of feebleness or flexibility.

93. Fo, *to fly, to float;* fo-fo, *foam.* Cfr., forth, fowl, A. S., fugl, Ger., vogel = fo gele, *to fly high* (gele, *to be elevated, raised above the surface,* from ga, *high,* ele, *an eminence*); Chin., fei; Eg., fai, pai, pa; Sans., pat, *to fly;* foam, Ger., faum; Lat., fumo (fo, *to float,* ma, *to wander*). With this root is probably allied the preposition fu, *for, to, of, by, with, on account of.* Cfr. Ger., für; Eng., for.

94. Giga.—Ga, *to be high, tall;* ga ru, *to rise high* (Sans., guru, Ger., gross, *great*).

95. I, *he;* i si, *he is,* or *it is he.* Cfr. Lat., is. I is the contracted or citative form of oŋ, or ŏŋ. Cfr. Dak., is′, iye, which is used both in the singular and plural.

96. Idaro.—"That which becomes collected-into-a-mass."

97. Idi, *an eagle;* iguŋ, *a vulture;* gunu-gunu, *a buzzard.* Cfr. Gr., *ἀετός, γύψ.*

98. Igŏŋ; i, *that which,* guŋ, *stabs.*

99. Ihiŋ.—Cfr. ha, *to be narrow,* hiha, *narrowness;* Goth., hidre, *hither.* See čhiŋ, § 82. The idea of backwardness (čhiŋ) may be associated with that of nearness or narrowness (ihiŋ), by thinking of something which has gone away, and is coming back.

100. Ika, *cruelty, wickedness;* ka, kaka, kako, *presumptuously, to be strong, stiff;* kaŋ, *to oppose;* Cfr. Gr., *καζός.* Webster compares *wicked* with Sw. vika, *to decline, to err, to fold;* Sax., wican, *to recede,* wicelian, *to vacillate, to stumble;* and says it seems to be connected in origin with *wag,* and Sax. wicca, *witch.* Cfr. Yor., awiriŋ, awika (in al-awika), *a wizard, a witch;* ka, *around, to fold;* we, *to twist, to fold;* Sans., **pratiha′rica**ˢ, *a juggler.*

101. Ikaŋ, *cane with which chairs are bottomed;* i, *that which,* kang, *to pierce, to bore, to nail.* Cfr. Chin., kăng, *straight, erect, to prick as a thorn;* kan, *rod, reed, cane, to pierce;* Gr., *κάννα, κεντέω.*

102. Iri, *dew, mist, sight, that which is seen.* Cfr. Eg., iri, *eye;* Gr., *ὁράω, ἶρις.*

103. Iriŋ.—"That which is heavy." v. Eriŋ, § 79.

104. Itele, *the leg of a beast.* Tĕ, *to spread out, to push forward, to trample;* tĕlĕ, *to pursue, to trample on.* Cfr. Lat., talus; Fr., Eng., talon.

105. Iwora, wŏbia, *greediness;* wŏra = wŏ ara, *to enter into one.* Cfr. Gr., *βορά.*

106. Ka, ko, *to gather, to fold, to roll, around;* kĕkĕ, *a wheel;* kĕkĕru, *a cart* (ru, *to carry*); kiri, *to wander, to stroll;* makari, *compasses, dividers.* Cfr. Eg., kar, *an orbit;* kara, *sarcophagus;* karas, *coffin, embalmment, mummy;* kab, *to fold;* Sans., **cacſa**ˢ, *a girdle;* **ca′ra′**, *a prison, binding;* **tſacra**ˢ, *a wheel;* Heb., כרך, *to bind;* כרכב, *a circle;* Gr., *κίρκος, κύκλος, κύλινδρος, κυλίω;* Lat., carcer, circum, curvus, currus.

107. Kata-kata, fĕka, fŏŋka, tuka, *to scatter.* Ka, *around, on;* ta, *to spread, spill, pour;* fĕ, *to blow;* fŏŋ, *to sow,* tu, *to untie, loosen, pour out.* Cfr. Gr., *σκεδάννυμι, κατά;* Lat., scateo; A. S., scateran; Eng., scatter.

108. Ke.—Probably from the primitive ka, *to surround, enfold, embrace.* Cfr. *caress, cherish.*

109. Kele, *gently:* kĕkĕ, *profound silence.* Cfr. Eng., *calm.*

110. Ki, *what?* Cfr. Sans., **ci**,?

111. Kiŋkiŋ, *a very little portion.* Perhaps derived from ki, *not,* or ke, *to cut.* Cfr. Eng., *-kin.*

112. Kiri. See Ka, § 106.

113. Kole.—From ko, *to gather, to collect,* or kŏ, *to build, to dig earth into heaps,* and ilĕ,

ground, earth. In a similar manner we may derive Ger. hügel, and A. S. hill, from Ger. hoch, Du. hoog (E. huge), A. S. hih, and ilĕ.

114. Koŋ, *to sing.* Cfr. Chin., Sans., can, *to sound:* Lat., cano. See Akŏŋ.

115. Kuru.—Ku, *to die, to terminate, to be blunt or dull:* ra, *to perish, to dissipate:* ru, *to be lean.* Cfr. Chin., ko, *inclined to sleep:* Gr., κῶμα.

116. Le, *to be strong, healthy, to lay upon:* mbĕ, wa (= ba?), *to be:* bi, *to be, to beget:* Cfr. Goth., A. S., liban; Ger., leben; Chin., leĕ, *to arrange in order:* leih, *strength:* we, *to be:* Gr., λέγω.

117. Le, *to be sluggish, lazy.* Cfr. Chin., lan, lan-to (M. 6905); Lat., lentus; Ger. lass.

118. Lo, *lukewarm.* Cfr. Chin., lŏ, lŏc, *to burn;* A. S., vlaco; Ger., lau.

119. Lŏ, lu, *to strike, to play a stringed instrument, to beat a drum.* Cfr. Ger., laute; Eng., lute.

120. M, "the sign of continuance or permanence;" ma, *an auxiliary particle*, conveying the idea of *continued action.* Cfr. Lat., maneo. The verb mbĕ, *to be*, denotes existence *absolutely* or *permanently*, like the existence of God. The derivative connection that has already been pointed out between ni, m, and n̄, *to be* (v. Emi, § 75), shows an analogy with the idiom of the Dakota language, in which "verbs signifying *to be* are repeated to denote continuance."—*Riggs, p.* 53.

121. Mah, *not.* Cfr. Eg., am. See E, § 74.

122. Makari, *compasses.* See Ka, § 106.

123. Medźi, *two* (= mŏ, *again*, edźi, *two*); agbedemedźi, *the middle, midst* (= a *that which*, gbe, *makes*, de mŏ, *to bind to*, e, *that which*, dźi, *is distant* or *separated*). Cfr. Sans., madhya; Gr., μεσίδιος, μετά; Lat., medius, dimidium; Goth., midja; A. S., middel. Webster's conjecture of an alliance between *middle, meet,* μετά, &c., appears to be justified and explained by this analysis. The natural lapse of the di into dźi, is exemplified in the Yoruba preposition di, *from,* = dźi, *to be distant,* and da, dźa, *to break.* The Sans. dvi, dvaus, *two* (Chin., tuy, *a pair*, M. 11,443), may be compounded of di, *from*, and wŏ, *to go.*

124. Mŏ, *to be light* (as day), *to shine, to be clear, to know, to understand.* Cfr. *morning.* See Egbĕra, § 81.

125. Ni.—Cfr. Gr., poet, ἐνί; Dak., en.

126. Niha, Nikusa; ni, *in:* ha, *to be narrow, crowded:* ka, ko, *to gather, to collect:* se, *to shut* a door, *to close up*, s'a, *to collect.* Cfr. A. S., neh, neah; Ger., nahe, nach; Eng., nigh; W., nig, *narrow.*

127. Ore.—Cfr. ri, *to see:* Eg., iri, *eye.*

128. Oro.—Cfr. ro, *to stand erect, to excite:* Gr., ὄρος, ὄρω.

129. O, o̩, I, Mah, *not.* Cfr. Chin., we, wei, woo, me, mei, mŏ, Gr., μή, οὐ. The κ in οὐκ, may be equivalent to Yor. ko, Dak. ka, *not.*

130. O, ọ, Iwŏ, *thou:* eŋyiŋ, ŋyiŋ, *you.* By the aid of the particle of extension or distance, ti, *from, of, by, who, which, that,* we may form ti iwŏ = tuwŏ; Cfr. Sans., tva,, tva′, tava; Lat., tu; Gr., σύ (Dor., τύ), the σ being substituted for τ, as in Sans. tad, *nom,* sas. The wo appears in Lat. vos; the o, modified into υ, in Gr. ὑμεῖς; the yi in Eng. ye, and Dak. incorporated ya, ye; yi + iwo =yuwo in Sans. yuva′, and the modified n̄ in A. S. ge. As ni = m = ŋ (v. Emi, § 75), the ŋ in ŋyiŋ, the μ in ὑμεῖς, and Dak. ni, may all have sprung from the same origin.

131. O, ọ, Oŋ, Oṉ, *he, she, it;* awŏŋ, nwŏŋ, wŏŋ, *they.* Cfr. Fr., on. In awa, *we, our, us,* iwŏ, *thou, thy, thee,* awŏŋ, *they, their, them,* there is apparently an identical compound root, which has been modified so as to distinguish its several applications. That compound is probably a or i, *that which,* wa, *is.* With the demonstrative ta prefixed, it becomes tawa, which is equivalent to Sans. tava, *thy,* "*that which is*" *there,* and to the Dakota possessive tawa, in mitawa, *my:* nitawa, *thy:* tawa, *his:* uŋkitawapi, *our* (Ger., unser); nitawapi, *your:* tawapi, *their.* Perhaps the analogy between oŋ and Fr. on, may be considered more important, if we observe that oŋ also signifies *and,** as if the two things connected were an-d, or one-d (Cfr. Ger., und; Dan., og; Du., en; Dak., uŋkaŋ). The use of the same root for the substantive verb and for unity, may be observed in Dak. waŋ, *a* or *an,* waŋća, *one,* uŋ, yaŋka, waŋka, yukaŋ, *to be:* Yor., ni (= ŋ), *one, to be:* Eg., au, *to be, and* (Cfr. Ger., auch); u, *to collect:* ua, *one:* un, *to be* (Cfr. D. uŋ; Lat., unus); Gr., εἷ-ς, εἰ-μί, εἶν-αι (Cfr. Ger., ein). The ća or ka in waŋća waŋka, may be identical in origin with the similar sound in Yor. ka, Eg., s-ka, *to collect:* Sans., ecas, *one:* tʃa, *and, also:* tʃi, *to collect:* Eng., each; Gr., και; Dak., ka, tʃa, *and,* tʃi, *with:* Chin., y or yih, *one, to unite in one, also:* Span. y.

Wedgewood has happily developed Tooke's idea of the radical connection of and with an, *if, whether:* Webster adopts the hypothesis of Skinner, that *and* is equivalent to *add,* with an epenthetic *n.*† Tooke quotes also the conjectures of Casaubon and Lye, the former tracing the word to εἶτα, and the last to ἔτι. I am not aware that any one has suspected an affinity to the indefinite article *an,* or that any attempt has ever been made to reconcile these apparently conflicting hypotheses. I think this reconciliation can be satisfactorily effected, through the three Yoruba words, abi, ani, ati, each of which is employed to denote *that which has* anything. Abi and ani also signify *that which is,* and are therefore exact synonymes with awa, the three words being derived in the same manner from bi, ni, and wa, *to be.* Awa, ama, and aba, are so nearly alike, that we might reasonably suppose them all to have sprung from the same root. This supposition is confirmed

* Bowen says, "oŋ, *and,* appears to be the pronoun óŋ, *he,*" (p.17), but he does not attempt to show the connection between the two meanings. Bunsen compares Eg. au, with Ger. auch and Dan. og.

† Diversions of Purley, London ed. 1840, pp. 70, 117.

by the fact that, as we have already seen, m is used in Yoruba, as well as b and w, to represent continued existence. Yor. aba, *with* or *together;* Gr., ἅμα; Eg., am, *with*, and Sans., eva, *also* (ewa = awa in Yor., Cfr. Eng., even), are, therefore, apparently identical words.

Bowen says (p. 29), "the origin of the particle 'ti' is doubtful. It is not improbably, however, a modification of to, *to be sufficient, to attain to,* which is sometimes employed as a sort of auxiliary particle." The same radical meaning is traceable in ta, *to shoot forth* branches, *to go from place to place*, and tĕ, *to spread out, to push forward, to approach, to be near.* Hence, ti, 1, *to thump, strike against, lean against, prop, support;* 2, *to lock* or *fasten, tie, bind;* 3, *that, who, which;* 4, *from, of, by, and;* 5, *auxiliary* or *possessive part., have, has, had* (as if to denote that which is *tied* to one, or *by* one). De and di have many of the same meanings, and are undoubtedly from the same root. It appears, therefore, that the only radical difference between abi, ani, awa, and ati, is found in the more definite idea of nearness to some object, that is expressed by ati. They all signify "that which is," but ati also means that which is *at* or *to* one. See Ati, § 59. Cfr. Chin., te, *to arrive at, push with the horns, rush against, oppose, bind with leather straps, to, for, to grasp with the hands.*

In the various significations of de, di, ta, te, ti, *to lay, spread out, erect* (as a tent or altar), *bind, possess*, it is easy to discover the origin of Sans. dha, Gr., θη, *to place*, as well as of the kindred English forms do, did, and the preterite ending -d.* Curiously enough, we find the preterite inflection retained in Yoruba grammar, in its primitive radical form; e. g., emi fĕ, *I love;* emi ti fĕ, *I possess love* = I love-d, or I have love-d. In the optative mood we find, besides the interesting form ma = Chin. mang, Ger. mag, &c., to which allusion has already been made, the still more interesting ma ti = Chin. mang te, Ger. mög-te, Eng. migh-t; e. g., emi ma ti ri, *I migh-t have seen.*

The correspondence in meaning between Yor. ni and ti, is further borne out by the root na, which, like ta, te, ti, signifies *to stretch, extend, that.* Ana would, therefore, = "*even*, in the sense of continuous, unbroken, level," which Wedgewood conjectures to have been the primitive meaning of an, *if.* One of the Yoruba forms of the verb to be, thus appears to have become the basis of Gr. ἄν, Lat., Eng. an, while another is retained unaltered in Yor. bi, *if.* Cfr. Tooke's derivation of if from gifan,† = Ger. ge-*ben.*

132. Ọrŏ, *wealth, clay.* "That which is scraped together; collected into a mass." Cfr. It., oro; Fr., or.

133. Ọrŏ, *a word, conversation.* "That which tells, or sounds." Cfr. Lat., verbum, oro (Cfr. Yor., tŏrŏ, *to beg*); Dan., Sw., ord; A. S., Eng., word.

134. Ọruŋ = ŏ ru ni? *that which is elevated or swollen*, or ŏ raŋ, *shining.* This word

* See Müller's Lectures, pp. 231–4. † p. 70.

suggests a number of interesting philological ramifications. The association of the ideas of elevation, light, and heat, with the sky, is so natural, that we may reasonably expect to find, through the words that express those ideas, traces of very early family affinity. That expectation is realized in 1, S. hi, *to grow, to enlarge;* hetiˢ, *flame;* 2, D. T.,* ᶜhe, *a mountain;* ᶜhewaŋke, "*lying on the mountain,*" *frost* (Cfr. S. hima, L. hiems, Gr. χειμών); ᶜhemlo, ᶜhemlaya, *hill-top, ridge, mountain-level* (Cfr. S. hima'laya, L. pla-nus = D. T. mla); G. hitze, hügel, himmel (which, like the Greek Olympus, may possibly have been taken from the fancied abode of the gods in a mountain range); 4, E. heat, hill, high, heaven (= heaved, or high); 5, A. S. har, H. הר, *hoary;* חר, *a mountain;* 6, C. he, *dangerous mountains, the color of the sun, light, very hot,* M. 3311, 3338-9; heuen, *heaven, to rule,* M. 3663, 3820. Him-a'laya, = "the cold abode," is not so closely connected with the Dakota form hemlaya, as it appears at first glance. But the remote connection is still more interesting, inasmuch as it shows that a primitive etymological vinculum may exist where we least expect to find it. Cfr. Y. ra, *to lay one thing on another;* bele, bere, *flat, level;* ile, *a house, ground, earth;* D. T. mla, *smooth, flat;* ehle, *to lay;* mle, *a lake;* L. pla-nus, lacus; Gr. λέγω; E. lake, lay, level, flat.

Another primitive root, la or ra [with its modifications wa and ma], either simple, nasalized, or gutturalized, is found in 1, C., laou, *large,* M. 6925; lang, *lofty, bright and clear,* M. 6912 (Cfr. G. lange; L. longus; A. S., Du., Dn., lang); ling, *a mountain,* M. 7269; lung, *conspicuous, glorious, rising high in the centre as the summit of a mountain,* M. 7399 (Cfr. ὄ-λυμ-πος); lok, *the bright dazzling glare of water,* M. 7302 (Cfr. L. luc-); 2, Eg. ra, *sun, day;* rkh, *heat* (Cfr. S. rcfa, *star*); 3, Y. la (in ni-la), *large;* raŋ, *to shine;* oruŋ, *sun, sky;* re, *to go* (Cfr. S. r, L. ire); ru, *to rise, swell;* 4. S. uru, *great;* ra'visˢ, *the sun;* ra'dɟ, *to shine* (Cfr. L. rad–, verus); 5. S. Afric. and Polynes. la, lang, &c. See ante, § 36, 38.

The Chinese having no r sound, usually represent it by l, but sometimes by w, which they often interchange with m. We therefore find 1, C. mang, M. 7509, 7515 = wang, M. 11621 = lang M. 6912, *vast, wide, great.* The ideas of power, government, law, flow naturally from that of greatness, and we have 2, C. wang, *the sun going forth and shedding abroad his illuminating beams,* M. 11620; wang, *a ruler,* M. 11618; mang, *strong, a senior or superior,* M. 7515-6 (Cfr. L. magnus, major, magister); lang, *the majesty of divinity,* M. 6920; laou, *venerable,* M. 6923; le, *human reason, to govern,* M. 6942 (Cfr. L. re-go, ratio); lik, *strength, to establish, to erect, to form or fix, to put in order, to restrain,* M. 7111-3, 7217 (Cfr. λέγω; L. lego, lex, erigo; S. ra'dɟ *to rule;* E. reign, regular, rectitude; D. T.* ilaka, *to govern.* Cfr. also Malay, languit, orang; Eg. ra, ruma; S. bhanus, manuſas; D. wi, wic'a (= *sun, man*); L. vir, vireo, vividus; Y. ko, *to flash,* kuŋ, *to burn,* ako, *male,* akoŋri, *man*); ling, M. 7249, *to govern, law.* Speech, as the directing faculty, is repre-

* Titoŋwaŋ dialect of the Dakota language.

sented by 3, C. ling, *to order, to enjoin upon*, M. 7249; low, *loquacity*, M. 7341 (Cfr. D. T. la, *to ask, demand;* S. loc; L. loquor, lingua; Gr. λέγω; G. laute; E. loud).

The occasional use of y for w, r, and their cognates, is perhaps indicated by 1, C. yang, *vast, abundant*, M. 11869; yang, *a rule, a pattern*, M. 11873; yang, *the light of fire, clear, bright*, M. 11891, 11899; yen, *to speak* (Cfr. D. ia, *to speak*), M. 12009; yen, *the eye*, (Cfr. S. nayana, H. עין), M. 12078; 2, C. mih, *the eye*, M. 7682; muh, *the eye*, M. 7803 (Cfr. Eg. r, *a mouth*, iri, *the eye*; Y. ri, *to see;* li, wi, *to say;* ro, *to tell;* Gr. ἐρέω, δράω).

135. Ọta, *an enemy, adversary.* "He who shoots or attacks." Cfr. Lat., hostis (Yor. ọ = Gr. ὀς). Odi, *malice.* Cfr. Lat., *odium.*

136. Raŋ, *to twist, to spin, to send, to communicate* (as fire or infusion), *to shine;* raŋ ikpo, "to twist double," *to speak ironically.* Cfr. Gr., ἀράχνη, ἔιρω, εἰρωνεία; Sans., ra′dɟ, *to shine;* Eng., rank, range?

137. Rŭ. Redness is expressed in Yor., both by rĕ and ro (in roro, *with a fine red color*). The root ru is found in Dak. duta = ruta, *red, scarlet.* Cfr. Sans., rohitaṣ, *ruddy:* Gr. ἐρυθρός, ῥόδον; Lat., roseus, ruber; A. S., reod.

138. Ro, *to turn from a course or position, to yield or give place.* Cfr. Sans., vrt, *to turn;* Lat., rota, rotundus; It., rondo; Eng., round.

139. Rudi.—From ri, *to be, to have*; idi, "that which binds or is bound," *a sheaf, bunch, source, cause, reason.* Cfr. Lat., rudis, rudimentum, erudio.

140. Si, S′e, *to be.* Cfr. Lat., esse; Gr., ἐσ-; Ger., seyn; Eng., is.

141. Sibĕ, *there;* si ibĕ, *to that place.* Cfr. Lat., sibi.

142. Sŏŋ, Suŋ, *to broil, to burn;* gusu, *the south.* Cfr. Arm., su; A. S., suth; Ger., Dan., Fr., sud; Lat., sudor.

143. Su-a, *is good, nice, well.* Cfr. Sans., su, *fine, pleasing.*

144. S′afĕri.—Bowen derives this word from s′e, *to be*, a, *one who*, fĕri, *seeks.* He refers fĕri to ori, *the head*, but does not explain how it obtains its meaning. S′a signifies *to pick out, select.* In Dakota, we find ksa, *to separate*, pa (= Eg. pa), *the head*, ksapa = "the separating or discerning head," *a wise man.* Cfr. Gr., σοφός; Lat., sapio.

145. S′ĕkĕs′ĕkĕ; s′e, *to be, make;* kĕ, *to set a snare;* ka, *to fold around;* ka . . lara, *to entangle*, as a net. Cfr. D., schakel, *a link or mesh;* A. S., sceacal.

146. S′os′o, *singly, only.* Cfr. S′a, Chin. shŭh, *to collect;* Lat., solus.

147. S′os′o, *to bewitch;* s′e, *to be*, os′o, *a witch.* Cfr. Chin., shŭh, *witchcraft;* shŭh soo, *a kind of magic arts or calculations, which are illegal.*

148. S′okaŋ; s′e, *to be;* ŏkaŋ, *one, the same.*

149. Tĕrĕ; tĕ, *to spread out, to push forward;* rĕ, *to increase.* Cfr. kĕ, *to extend;* gele, *to be elevated;* Gr., γέρανος; Lat., grus; Ger., kranich (Cfr. genick, *neck*); Dan., krane, trane; Sw., trana; Dak., pehaŋg′idaŋ (g′idaŋ = g′iraŋ); Eng., crane, heron.

150. Toto, Tŏtŏ, Tutu; to, *to reach, to be sufficient, to lay up;* tu, *to pour out, to gush.*

151. Tu.—Cfr. Chin., too; Sans., ſtiv, *to spit.*

152. Wo, *to be hollow, to enter into, to abide in a house.* Cfr. Ger., wohnen.

153. Wŏwŏ, *to be lukewarm.* Cfr. Goth., Ger., D., Eng., warm.

154. Wura; wu, *to please;* ra, *to buy?* v. Orŏ, § 132.

155. Ye, *to be pleased;* yĕ, *to turn out of place, change;* yi, *to turn, revolve.* Cfr. Chin., yĭh, *to be pleased, change, to revolve;* ya, *to laugh.*

156. Yŏ, *to rejoice.* Cfr. Chin., yu, *joy;* Lat., jucundus; Eng., joy.

157. Yuŋ, *to conceive, to be pregnant;* ye, *to lay eggs, to live;* Cfr. Chin., jĭh, *to enter, to receive, to put within;* jin, *pregnant;* Sans., **dji´v**, *to live;* **djan**, *to produce;* **yuvan**, *young;* Lat., juvenis; Eng., young, yean.

158. On account of considerations which I may have accidentally overlooked, I am willing to make a much greater allowance than is justified by our mathematical investigation, for the probability that many of the foregoing resemblances will finally prove to be destitute of any etymological value, that many others will have only an indirect and remote significance, and that perhaps very few will prove to be fraught with any general and permanent interest. But even if a single one shall be found to indicate a resemblance which cannot be satisfactorily explained as accidental or onomatopoetic, between two languages that are so widely separated as the Yoruba and Dakota, or the Yoruba and Chinese, my labor will neither have been in vain, nor will its usefulness be confined to the gratification of an idle and futile curiosity, or to the author's personal satisfaction from a pleasant occupation for many studious hours. The wide field of interesting, successful, and profitable research, that was opened by Horne Tooke, encourages me to hope that an unlimited extension of even his primitive and imperfect methods of analysis into regions where only such primitive methods are as yet available, would sow the seed for a future bountiful philological harvest; a harvest that would help, in combination with the discovery of Mongol skulls in the Tinniére, and the manifold evidences of repeated waves of Asiatico-European migration, to bring us back to the full realization and enjoyment of that feeling of universal brotherhood, which accompanied the catholic faith of our fathers,* that God "hath made of one blood all nations of men for to dwell on all the face of the earth."

* Is not the foundation of that faith greatly strengthened by even a single instance of such resemblance as is to be found in the Indian "Manitou" = Eg. ma nter = C. mang taou, M. 9945 = L. magn-us deu-s = Gr. *μέγ-ας θεό-ς* = S. mah-a dev-a?

INDEX.

a, Eg. 17; Y. 50 to 62, 84, 131; Gr. 74; Ic. 59.
ab, L. 25.
אב, 34.
aba, Y. 131.
abetele, Y. 48, 50.
abi, Y. 48, 51, 131.
abiamo, Y. 35.
abo, Y. 50, 64.
acies, L. 53.
ad, L. 59.
adaba, Y. 48, 58.
adi, Y. 48, 59.
ᾱεί, 62.
aequalis, L. 81.
ᾱήρ, 40.
aetas, aeternus, aevum, L. 62.
ᾱετός, 97.
afara, Y. 71.
agbami, Y. 81, 42.
agbedemedȷi, Y. 123.
ᾱγών, 48; agoŋ, Y. 48, 52.
aha꜀, S. 75, 17.
ai, Y. 74.
αἴξ, 48.
ᾱιών, 62.
aivs, Go. 62.
ᾱχή, 53; ake, Y. 48, 53, 54.
ako, Y. 32, 56, 81.
akoŋ, Y. 48, 55.
akuko, Y. 48, 56.
akuŋ, Y. 48, 55.
al, A., Y. 84.
am, Eg. 121, 131.
ama, Y. 131.
ᵓαμα, 131.
ami, Y. 57.
amo, Y. 35.
amona, Y. 48, 57.
ᵛαν, 131.
an, E. 131; A. S. 59.
ana, Y. 131.
anak, anog, anok, Co. 17.
and, E. 131.
anek, Eg. 17.
ani, Y. 131.
anig, A.S.. 85.
anuk, Eg. 17.
any, E. 85.
aŋ, aŋpe, D. 36.
aqua, L. 81.
ar, I. G. 39, 78; Eg. 48.
ara, Y. 77.
aránu, P. 78.
arare, L. 39.
arátfic, Cr. 78.
ἀράχνη, 136.
arbeit, G. 78.
aries, L. 86.
aro, Y. 78.
ἀροῦν, 39.
ars, L. 78.
arunaꞩ, S. 60.
a′rya, S. 78.
asa, asaloh, aso, Y. 88.
asal, A. S. 88.
ascia, L. 53.
asilus, Go. 88.
asinus, L. 48, 88.
asmat, S. 75.
ἀστήρ, 36.
aǫri, S. 53.
aǫvaꞩ, S. 88.
aftra꜀, S. 36.
at, Eg. 34, 59; E. 59, 131; Ic. 59.
ata, Y. 48, 58.
ataba, Y. 48, 58.
atai, Eg. 34.
ate, D. 34.
atf, Eg. 34,
ati, Y. 48, 59, 131; Eg. 59.
atn, Eg. 34.
ato, Y. 32.
au, Eg. 25, 131; F. 25.
auch, G. 131.
aui, auu, auru, Eg. 60.
auro, Y. 48, 60.
aurora, L. 44, 48, 60.
aurum, L. 48, 60, 154.
av, I., F. 25.
avyaya, S. 62.
a′wa′꜀, S. 75.
awa, Y. 17, 131.
aware, E. 48, 61.
awari, Y. 48, 61.
awika, Y. 100.
awiriŋ, Y. 100.
awoŋ, Y. 55, 131.
awu, Y. 59.
awudźe, Y. 60.
axe, E. 48, 53.
ἀξίνη, 53.
aye, E., Y. 62.
ayida, Y. 62.
ayuf, S. 62.
ba, Y. 50, 64, 58, 66; W. 51.
baba, Y. 34; Eg. 40.
bag, E. 50.
bah, E. 40.
baita, Eg. 48.
בכש, 50.
bale, Y. 48, 63.
βασιλεύς, 48, 63.
bata, Y. 9, 64.
בת, 9, 48.
be, Y. 50, 91; E. 51; D. 67.
beef, E. p. 27.
beg, E. 50.
bele, Y. 134.
beo, Go. 51.
beon, A. S. 51.
bere, Y. 134.
beru, Y. 48, 66.

bhicſ, S. 50.
bhirus, S. 48, 66.
bi, Y. 51, 67, 116, 131.
βίος, 48, 51.
bioth, Ir. 51.
bitteln, G. 48, 50.
bo, Y. 50, 55, 64, 81.
boeuf, F. p. 27.
boot, E. 64.
βορά, 105.
boro, Y. 55.
bota, botella, botila, Sp. 64.
botte, I., F. 64.
bottiglia, I. 64.
bottle, E. 64.
βοῦς, 65, p. 27.
boute, F. 64.
bouteille, F. 64.
bouton, F. 64.
bov-, L. p. 27.
βουτίον, βουττίον, 65.
broad, E. 71.
bu, W. 51.
bud, E. 64.
βυτίον, 65.
butt, button, E. 64.
βόω, 64.
cacſaꞅ, S. 106.
call, E. 55.
calm, E. 109.
can, C., S. 114.
cano, L. 114.
capio, L. 51.
cárá, S. 106.
carcer, L. 106.
caress, E. 48, 54, 108.
carus, L. 54, 48, 108.
cesso, L. 68.
cherish, E. 108.
chill, E. 73.
choo, C. 34.
ci, S. 110.
circum, L. 48, 106.
columba, L. 58.
collis, L. 28.
colo, L. 48.
conch, E. 55.
contra, L. 52.
crane, E. 149.
cucuta, S. 48.
currus, L. 106.
curtus, L. 48.
curvus, L. 106.
curved, E. 55.
—d, E. 131.
da, Y. 48, 73, 123.
dake, Y. 68.
dare, L. 48.
dark, E. 72.
de, Y. 59, 69 to 72, 131; L. 70.
delay, E. 48, 71.
de mo, Y. 123.
δέω, 59, 70.
deore, A. S. 72.
δηρός, 73.
deus, L. 36, 158.
deva, S. 36, 158.
dhara, S. 39.
dha, S. 131.
dhu, Sc. 72.
di, Y. 73, 123, 131, 59, 69, 70.
dies, L. 36.
dile, Y. 71.
dilatory, E. 71.
dilu, Y. 73.
dimidium, L. 123.
div, divas, S. 36.
dive, E. 58.
dȷa, Y. 123.
dȷal, S. 73.
dȷala, S. 81.
dȷan, S. 157.
dȷanuꞅ, S. 55.
dȷaŋgboro, Y. 55.
dȷe, Y. 73.
dȷi, Y. 123.
dȷi'v, S. 157.
dȷo, Y. 40.
do, E. 131.
dove, E. 58, 48.
dross, E. 48, 96.
du, Y. 72.
dun, E. 72.
durmak, T. 73.
duro, L., Y. 48, 73.
durus, L. 73.
duta, D. 137.
dvauꞅ, dvi, S. 123.
dyauꞅ, dyu, S. 36.
e, Y. 66, 74, 76, 84, 88, 90; Co. 25.
ear, earn, earth, E. 39.
ecaꞅ, S. 48.
edȷi, Y. 123.
efufu, Y. 80.
egbera, Y. 81.
ego, L. 17, 75.
ehde, ehle, D. 134.
ehiŋ, Y. 82.
ein, G. 131, 48.
εἶρω, εἰρωνεία, 136.
εἶς, 131.
εἶτα, 131.
ek, Eg. 17.
eka, Y. 83.
ekaŋ, Y. 48, 83.
ekuŋ, Y. 55.
ekuru, Y. 78.
el, Y. 84.
ele, Y. 73.
ἥλιος, 44, 45.
ἡμ-, 75.
ἐμέ, 17, 48, 75.
emi, Y. 17, 48, 75.
ἓν, 48.
en, Du., 131; D. 125.
eni, Y. 48, 76, 85.
'ενί, 125.
ἕνιοι, 48.
ent-, Eg. 17.
ente-, Eg. 28.
eŋyiŋ, Y. 130.
eraŋ, Y. 86.
ere, Y. 77, 78.
'ερέω, 77, 134.
erigo, L. 134.
eriŋ, Y. 79.
ero, Y. 77.
eru, Y. 39, 66, 78.
erudio, L. 139.
erukpe, Y. 39, 78.
'ερυθρός, 60, 137.
es, Eg. 17.
'ες-, 140.
ese, Y. 87.
esel, G. 88.
esse, L. 140.
eſiŋ, Y. 48, 88.
et, L. 59; Eg. 17.
—et, Eg. 28.
etad, S. 17.
ἔτι, 48, 131.
etiam, L. 62.

eto, Y. 89.
ἕτυμος, 89.
eurus, L. 48.
eva, S. 131.
even, E. 181.
eyi, Y. 90.
f, Eg. 17.
fa, Y. 71.
fai, C., Eg., 93.
fan, C. 39; E. 91.
faum, G. 93.
fe, C. 67, 91; Y. 91, 107.
fear, E. 48, 91.
fehiŋti, Y. 91.
fein, G. 92.
feka, Y. 107.
fere, Y., L. 48, 91.
fero, L. 71.
fi, Y. 91.
fiddle, E. 91.
fides, L. 91.
file, Y. 91.
filer, F. 91.
φιλέω, 91.
filo, Y. 91.
filum, L. 91.
fin, F. 48, 92.
fine, E. 92.
finis, L. 48, 92.
fiŋ. Y., 48, 92.
fiŋ-riŋ, Y. 91.
fio, L. 91.
firo, Y. 91.
fiti, Y. 91.
flat, E. 71, 134.
flecto, L. 91.
fo, fofo, Y. 93.
foam, E. 93.
foemina, L 33.
foŋ, foŋka, Y. 107.
foo, C. 33, 34.
for, forth, fowl, E. 93.
freuen, freund, G. 91.
friond, Go. A. S. 91.
fu, Y. 93, 48.
fugl, A. S., 93.
fung, C. 80.
φύω, 48.
für, G. 93.
ga, Y. 42, 94.
gba, Y. 81, 42, 94.
gbe, Y. 81, 123, 51.
ge–, G. 28.
ge, A. S. 130.
gegen, G. 52.
gele, Y. 43.
geler, F. 73.
gelu, L. 73.
genu, L. 55.
γέρανος, 149.
gere-gere, Y. 43.
gia, I. 62.
giga, Y. 43, 48, 94.
γίγας, 43, 48, 94.
giris, S. 43.
go, C. 17, 75; Y. 52.
γόνυ, 58.
γωνία, 48.
goŋ, goŋ–goŋ, Y. 52.
gori, Y. 43.
gross, G. E. 94.
grus, L. 149.
guardare, I. 61.
guŋ, Y. 98, 52.
γύψ, 97.
guru, S. 94.
gusu, Y. 142.
ha, Y. 99, 126.
habeo, L. 51.
hae, C. 42.
han, S. 52.
hanta, Fi. 82.
har, A. S. 134.
הר, חר, H. 134.
he, C. 134.
ʻhe, D. 134.
he, heyi, Y. 90.
heang, C. 82.
heat, E. 134.
heaven, E. 134.
ʻhemlaya, ʻhemlo, D. 134.
hence, E. 48.
heron, E. 149.
hetis, S. 134.
heuen, C. 134.
ʻhewaŋke, D. 134.
hi, S. 134.
hidre, G. 99.
hiems, L. 134.
high, E. 134.
hiha, Y. 99.
hill, E. 113, 134.
hima, hima'laya, S. 134.
himmel, G. 134.
hin, G. 48, 82.
hither, E. 99.
hitze, G. 134.
hoak, Sh. 53.
hoar, E. 134.
hostis, L. 135.
ht, Eg. 42.
hu, hv, H. 17; Eg. 43.
huge, E. 43, 113, 134.
hügel, G. 43, 113, 134.
i, Y, 48, 74, 84, 95, sqq., 129; H. 17; E. 75; Ic. 54.
ia, D. 134.
ibe, Y. 48.
ibi, Y., L. 48.
ich, G. 75.
idaka, v. ilaka.
idam, S. 17.
idaro, Y. 48, 96.
idi, Y. 97.
ife, Y. 91.
igi, Y. 59.
igoŋ, Y. 48, 98.
iguŋ, Y. 97.
ihiŋ, Y. 48, 99.
ika, Y. 100.
ikaŋ, Y. 101.
ilaka, D. 134.
ile, Y. 63, 71, 134.
ille, L. 84.
impingo, L. p. 32.
in, L. 74.
ire, L. 134.
iri, Y., Eg. 57, 127, 102, 134
iriŋ, Y. 48, 103.
ἶρις, 102.
iro, Y. 73, 81.
iron, E. 48, 103.
is, L. 48, 95, 84; E. 140.
ἶσος, 81.
if, D. 95.
itele, Y. 104.
iwo, Y. 130, 131.
iwora, Y. 48, 105.
iya, Y. 34.
iye, D. 95.
ja, je, G. 62.
jelly, E. 73.
jese, A. S. 62.

jih, C. 36, 157.
jin, C. 157.
joy, E. 156.
jucundus, L. 156.
juvenis, L. 157.
ka, D. 131; Y. 83, 54, 106, 126, 131, 145; Eg. 32; D. 129.
kab, Eg. 106.
καί, 131.
kaka, kako, Y. 100.
kakara, Y. 55.
κακός, 100.
ka...lara, Y. 145.
kan, C. 101.
kăng, C. 101, 55.
kaŋ, Y. 83, 100, 101.
κάννα, 101.
כף, 51.
kar, kara, karas, Eg. 106.
kara, Y. 55.
כרך, כרכב, 106.
kata, Y. 48, 107.
κατά, 107.
ke, Y. 108, 145, 48, 60, 43, 54.
keke, kekeru, Y. 106.
keke, kele, Y. 109.
κεντέω, 101.
χειμών, 134.
ki, Y. 110, 68.
ki‚, S. 17.
κίβυσις, κιβωτός, 64.
kin, C. 53.
–kin, E. 111.
kiŋ-kiŋ, Y. 111.
kiri, Y. 48, 112, 106.
κίρκος, 106.
klein, G. 68.
knee, E. 55.
ko, Y. 56, 113, 55, 106, 126, 83, 100, 129; C. 115.
kŏ, C. 55.
κόγχη, 55.
koksakin, Bl. 53.
kole, Y. 48, 113.
κολυμβᾶν, 58.
κῶμα, 115.
koŋ, Y. 42, 114, 55.
kpa, Y. 37.
krane, Dn. 149.
kranich, G. 149.
ksapa, D. 144.
ku, Y. 115.
κύκλος, κύλινδρος, κυλίω, 106.
kung, C. 32, 42, 45.
kuŋ, Y. 45.
kuru, Y. 48.
kwa, C. 81.
la, Eg. 36; Y. 65.
la, D., Y., S. Afr., Polyn., 134.
lă, C. 78.
lab, S. 81.
laba, Y. 50, 65.
λαβ—, 65.
lacus, L., 134.
lake, E. 134.
lai, Y. 62.
λαμβάνω, 65.
lan, C. 42, 40, 117, 78.
lang, C. 36, 42, 134; A. S., Dn., Du., S. Afric., Polyn., 134.
lange, G. 134.
laou, C. 62, 134.
large, E. 134.
lass, G. 117.
latus, L. 71.
lau, G. 118.
laute, G. 119, 134.
law, E. 134.
lay, lazy, E. 71, 116, 117, 134.
le, Y. 71, 117, 50, 71, 116; C. 71, 78, 134.
leather, E. 65.
leben, G. 116.
leĕ, leih, C. 116.
λέγω, lego, L. 71, 116, 134.
lentus, L. 117.
leof, A. S. 91.
level, E. 71, 134.
lex, L. 71, 134.
li, Y. 71, 84, 134; S. 81.
liban, Go., A.S. 116.
libet, L. 91.
libra, L. 81.
lieben, G. 91.
lik, ling, C. 134.
lingua, L. 134.
λίπτω, 91.
liubs, Go. 91.
lo, Y. 78, 118, 119.
lŏ, C. 118.
loc, C. 118, 134; S. 134.
longus, L. 134.
loo, C. 78.
loquor, L. 134.
loud, E. 134.
low, C. 134.
lu, Y. 119.
lubet, L. 91.
lubh, S. 91.
luc-, L. 134.
lufe, Y. 91.
lufian, A.S. 91.
luh, C. 78.
lung, C. 36, 78, 134.
lute, E. 119.
m, Y. 120.
m—, L. 75.
—m, L. 17.
ma, Y., L. 26, 120; Y., S., Eg. 81; C. 43, 134.
macſ, S. p. 31.
μαδάω, 40.
madeo, L. 40.
madhya‚, S. 123.
madekoso, Y. 81.
maegn, A. S. p. 31.
mag, G. 26.
μάγγανον, p. 31.
magister, magnus, L. 134, p. 31.
μάγος, p. 31.
mah, Eg. 40, p. 31; Y. 74, 121, 129; S. 158, p. 31.
ma‚h, mahat, S. p. 31.
mahidraˢ, S. 43.
mai, Eg. 26.
majestas, L. p. 31.
mak, Eg. p. 31.
maka, D. 78.
μάχαρ, p. 31.
makari, Y. 106.
μακρός, μαλα, p. 31.
mala‚, S. 78.
mama, D. 35.
mamodja, Y. 81.
μάν, 81.
man, C. 43.
mana-mana, Y. 44.
manaˢ, S. 81.
mane, L., Y. 44.
maneo, L. 120.
mang, C. 43, 26, 134; p. 31.
mango, L. p. 31.
maraŋ-maraŋ, Y. 44.

mare, L. 81.
ma's, S. 81.
matin, F. 44.
matutinus, L. 44.
matʃa, D. 37.
mau, Eg. 37; Co. 34.
may, E. 26.
mbe, Y. 51, 116.
mde, D. 40, 134.
mdetʃa, D. 78.
mdoka, D. 32.
mdu, D. 78.
me, C. 37, 40, 81, 129; E. 75, 17.
μή, 74, 129.
medius, L. 123.
medʒi, Y. 123.
meet, E. 123.
μέγας, 158, p. 31.
mei, C. 37, 40.
mekyl, Sc. p. 31.
memoro, L. 81.
μέν, *μήν*, 81.
mendax, mendico, mentior, L. 81.
μήνη, 81.
mero, Y. 81.
μεσίδιως, *μετά*, 123.
mete, Y. 81.
mi, Y. 81, 17, 57, 75; D. 75.
micel, A. S. p. 31.
mich, G. 17.
mickels, Go. p. 31.
mid, E. 123.
middel, AS. 123.
midja, Go. 123.
might, E. 131.
μίγνυμι, p. 31.
mih, C. 134.
mind, E. 81.
ming, C. p. 31.
mingle, E. p. 31-2.
mini, D. 40, 81.
mir, G. 75.
miror, L. 57.
misc-, L. p. 31.
mif, D. 75.
mix-, *μιξ*-, Gr., L., E. p. 31.
ml—, D. v. md—
mo, Y. 81, 124, 17, 75, 35, 36, 37, 57, 78; C. 78; D. 75.
mo, C. 78, 129, p. 27.
mögte, G. 131.
mole, Y. 65.
mona, A.S. 81.
mond, G. 81.
moneo, L. 48.
mongrel, E. p. 31–2.
mons, L. 43.
moo, C. 65, pp. 27, 34.
moon, E. 81; C. 43.
morning, E. 124.
mr—, D. v. md—.
mrd, S. 78.
mu, Eg. 34.
muai, Eg. 40.
mucel, A. S. p. 31.
much, E. p. 31.
mucho, Sp. p. 31.
muckle, Sc. p. 31.
muh, C. 134.
mung, C. 43.
mwan, C. 42, 43.
my, E. 75.
myche, Sc. p. 31.
mycken, Sw. p. 31.
n, Y. 62, 74.
na, Y. 65.
nahe, nach, G. 126.
nas, nau, S. 75.
nayana', S. 134.
ערן, H. 134.
ne, L. 74.
neah, neh, A.S. 126.
near, E. 126.
nese, A.S. 62.
ngo, C. 17.
ni, Y., S. 48, 125; Y. 75, 76.
nicaʃa, S. 48, 126.
nig, W. 126.
nigh, E. 126.
niha, nikusa, Y. 48, 126.
no, E. 74; C. 75.
νω—, 75.
non, L. 74.
nos, L. 17, 75.
nwoŋ, Y. 131.
ŋ, Y. 17, 75, 130.
ŋyiŋ, Y. 130.
o, Y. 25, 60, 74, 129 to 131; H, 17.
—o, L. 17.
ὁ, *ὁς*, 17.
oba, Y. 34, 63.
odi, Y. 135.
odĭum, L. 135.
odo, Y. 40.
odʒo, Y. 36.
og, Dn. 131.
ogba, Y. 81.
okaŋ, Y. 81, 148.
oke, Y. 43.
ὠκεανός, 42.
okuŋ, Y. 42.
olufe, Y. 91.
ὄλυμπος, 134.
omi, Y. 40.
on, F. 131; A. S. 59.
ona, Y. 57.
oŋ, Y. 131.
or, F. 132.
ὁράω, 48, 57, 102, 134.
ord, Da., Sw. 133.
ore, Y. 48, 127.
ori, Y. 43.
orior, L. 48.
oro, Y. 36, 48, 39, 60, 128, 132, 133; I. 132; L. 133.
ὄρος, 43.
ὄρος, 128.
ὄρω, 128.
oruŋ, Y. 36, 48, 134.
os'o, Y. 147.
oʃukpa, Y. 37.
ota, Y. 135.
oto, Y. 89.
οὐ, 74, 129.
οὐρανός, 48, 134.
owuro, Y. 36, 60.
pa, pai, Eg. 93.
pac-, L., C. p. 32.
pack, G., E., Sw., p. 32.
παγ-, *παχ*-, p. 32.
pan, C. 39.
pando, L. 39.
pang-, L., C. p. 32.
paç, paʃ, S. p. 32.
pax, L. p. 32.
pe, Eg. 51; C. 67.
πηγν-, p. 32.
pehaŋgidaŋ, D. 149.
peticá, S. 64.
peto, L. 50.
pi, S. 67.
planus, L. 134.

plat, F. 71.
πλατύς, 71.
πρᾶος, 91.
prath, S. 71.
pratiha'ricaˢ, S. 100.
prí, S. 91.
πτύω, 48, 151.
pu, Eg. 51.
πυτίνη, 65.
r, S. 39 to 42, 134; Eg. 77, 134.
ra, Eg. 36, 57, 60, 134; Y. 134, 71.
racta, S. 60.
radius, L. 60, 134.
rádȷ, S. 36, 60, 136.
ra¸dȷ, S. 60, 134, 136.
rain, E. 40 to 42.
ῥαίνω, 40 to 42.
ram, E. 86.
range, rank, E. 136.
raŋ, Y. 36, 86, 134, 136.
ratio, L. 134.
raviˢ, S 36, 134.
reſa, S. 134.
re, Y. 40 to 42, 48, 134, 137, 60, 78.
rect-, E. 134.
red, E. 137, 60, 48.
regen, rein, G. 40 to 42.
rego, L. 134.
reign, reg-, E. 134.
reod, A.S. 137.
ri, Y. 57, 61, 127, 134; S. 78.
rigo, L. 40 to 42.
ῥίν, 79.
rinse, E. 40 to 42.
riŋ, Y. 40 to 42.
rkh, Eg. 134.
rm, Eg. 40 to 42.
ro, Y. 39, 40 to 42, 60, 73, 77, 78, 81, 86, 128, 134, 137, 138; C. 77.
ῥόδον, 137, 60.
rohitaˢ, S. 137, 60.
roki, Y. 60.
rondo, I. 138.
roŋ, Y. 78.
ῥοπή, 81.
roro, Y. 60.
ros, L. 40 to 42.
roseus, L. 137, 60.
rota, rotundus, L. 138.
round, E. 138.
ru, Y. 60, 66, 78, 73, 134.
ruber, L. 137, 60.
rudi, Y. 48, 139.
rudimentum, L. 139.
ruŋ, Y. 78.
ruta, D. 137.
rutf, S. 60.
rχ, Eg. 40 to 42.
s, Eg. 33.
sa, S. 17.
ságaraˢ, S. 42.
sak, Eg. 33.
salio, L. 88.
sama, S. 81.
samudaˢ, S 42.
sanus, L. 48.
saŋ, Y. 48.
sapi, Eg. 33.
sapio, L. 144.
scateo, L. 107.
scateran, A.S. 107.
scatter, E. 107, 48.
sceacal, A.S. 145.
schaffen, G. 33.
schakel, Du. 145.
se, Eg. 17; Y. 126.
secundus, secundum, L. 87, p. 26.
sen, Eg. 17.
sequor, series, L. 87.
seyn, G. 140.
shape, E. 33.
shŭh, C. 146, 147.
shwuy, C. 40.
si, Y. 48, 62, 63, 140.
sibe, Y. 141.
sibi, L. 141.
sill, E. 86.
siŋ, Y. 82.
siŋte, D. 82.
s—ka, Eg. 131.
σχεδάννυμι, 107.
sn, Eg. 17.
sna, Eg. 33.
so, Y. 81.
soc us, L. 48, 148.
sole, E. 86.
solus, L. 146.
soŋ, Y. 142.
σοφός, 144.
σώφρων, 144.
south, E. 142.
su, Arm. 142; S. 143.
su-a, Y. 143.
sud, G., Da., F., 142.
sudor, L., 142.
suivre, F. p. 26.
su'nuˢ, S. 36.
suŋ, Y. 142.
sur, S. 36.
su'ryaˢ, S. 36.
suth, A.S. 142.
suy, C. 36, p. 26.
syu'nasˢ, S. 36.
ſa, Y. 146, 126, 144.
ſaferi, Y. 144.
ſe, Y. 140, 144 to 148.
ſeke, Y. 145.
ſiŋ, Y. 88.
ſokaŋ, Y. 48, 148.
ſoſo, Y. 146, 147.
ſtiv, S. 151.
ʂal, ʂval, S. 88.
ta, Y. 39, 58, 64, 42, 107, 131; Eg. 39; I. G. 82; C. 39.
tă, C. 39.
—ta, Eg. 28.
taceo, L. 68.
tad, S. 17, 130.
tae, C. 42.
talon, F., E. 104.
talus, L. 104.
tan, I.G. 82; C., S. 39.
tang, C. 39.
tăng, C. 36.
tango, L. 39.
tanus, S. 39.
taŋ, Y. 36; I. G. 82; D. 39.
tara, Y. 39.
taube, G. 48.
tava, I. 130, 131.
tawa, D. 131.
te, Y. 149, 131, 104, 42, 71, 82, 50; C. 39, 64, 71, 131.
tedium, L. 48.
tedo, Y. 48.
tele, Y. 104, 50.
ten, Eg. 17.
tenuis, tendo, L. 39.
tere, Y. 149, 48, 42.
teres, L. 48, 149.

terra, L. 39.
θη—, 131.
θεός, 36, 158.
ti, Y. 59, 130, 131, 71; D. 69.
tie, E. 131.
tige, F. 59.
tira, S. 39.
tle, Cher. p. 29.
to, Y. 42, 131.
too, C. 151, 39.
toto, Y. 48, 150.
totus, L. 48, 150.
trana, Sw. 149.
trane, Dn. 149.
tsaou, C. 60.
tʃa, D., S. 131.
tʃacras, S. 106.
tʃal, S. 81.
tʃi, S., D. 131.
tu, L., Gr. 130; Y. 107, 48, 151.
tuka, Y. 107.
tuli, L. 71.
tung, C. 36.
—tus, L. 28.
tutu, Y. 48, 150.
tuy, C. 123.
tva′, S. 130, 131.
tva, S. 17, 130.
tvara′, S. 45.
two, E. 123.
tyad, S. 17.
u, Eg. 17, 131.
ua, Eg. 131.
uda, u,d, S. 40.
ὕδωρ, 40.
ὑμεῖς, 130.
un, Eg., F. 131.
und. G. 131.
unda, L. 40.
uns, G. 75, 131.
unus, L. 131.
uŋ, D. 75, 131.
uŋkaŋ, D. 131.
uru, S. 134.
us, E. 75.
uvidus, L. 40.
vá, vari, S. 40, 81.
vato, Go. 81.
vaya, S. 17,75.
vayas, S. 62.
vegaˢ, S. 45.
verbum, L. 133.
vereor, L. 48.
verus, L. 134.
vi′, S. 67, 37.
—vi, L. 25.
vidyut, S. 45.
vika, Sw. 100.
vir, L. 134.
vlaco, A.S. 118.
vogel, G. 93.
voro, L. 48, 105.
vos, L. 17, 130.
vr, S. 61.
vṛt, S. 138.
wa, Y. 37, 61, 25, 81, 116, 134, 39; C. 39 to 41; D. 75.
wag, E. 100.
wakpa, D. 40, 41.
wakpukpa, D. 39.
wan, C. 40, 41.
wang, C. 134.
waŋ, waŋka, waŋtʃa, D. 131.
wara, Y. 81.
wari, Y. 37, 61.
warian, A.S. 61.
wariri, Y. 81.
warm, G., Go., Du., E. 153.
was, E. 25.
water, E. 40, 41.
wave, E. 81.
we, Y. 39 to 41, 81, 100; E. 17, 75; C. 33, 37, 129, 40, 41, 116; D. 75, 40, 41.
weave, E. 81.
weben, G. 81.
wega, D. 37.
wei, C. 33, 37, 129, 40, 41, 43, 45.
weibe, G. 33.
wele, were, Y. 45, 81.
wet, E. 40, 41.
wi, D., Y. 37, 134.
wican, A.S. 100.
wicca, wicelian, A.S. 100.
wicked, E. 100.
wife, E. 33.
wir, G. 75.
wiri, Y. 45.
witch, wizard, E. 100.
wo, Y. 123, 152, 55, 39; C. 17, 75.
wobia, Y. 105.
wohnen, G. 152.
woman, womb, E. 33.
woŋ, Y. 55, 81, 131.
woo, C. 129.
wora, Y. 105.
word, E. 133.
wowo, Y. 153.
wu, Y. 43, 60.
wura, Y. 48, 60, 154.
y, C., Sp. 131.
ya, Y. 62; D. 62, 130; C. 155.
yad, S. 17.
yang, C. 36, 134.
yaŋ, Y., D. 36.
yaŋka, D. 131.
ye, Y. 62, 155, 157; D. 130; E. 17, 130.
yean, E. 157.
yen, C. 134.
yes, E. 62, 90.
yeye, Y. 34.
yi, Y. 62, 155.
yĭh, C. 131, 155.
yo, Y. 156.
young, E. 157.
yu, C. 40, 156.
yuĕ, C. 37.
yukaŋ, D. 131.
yuŋ, Y. 157.
yuva′, S. 130.
yuvan, S. 157.
yuya, S. 17.
ζεύς, 36.
ȷaŋ, D. 36.
ȷaȷa, D. 40

NOTE TO ARTICLES II AND III.

Read May 6, 1864.

For the following interesting discussion, I am indebted to my friend JAMES EDWARD OLIVER, A.A.S., of Lynn, Massachusetts.

"1. Languages $\mathfrak{L}'$ and $\mathfrak{L}''$ are independent. $\mathfrak{L}'$ has a' *roots* or apparently independent combinations of sound, with as many meanings; $\mathfrak{L}''$ has a''. From these roots the words are formed. Neither language has two roots with one meaning, nor two meanings to one root. r roots are common to $\mathfrak{L}'$ and $\mathfrak{L}''$; so are m meanings; and (r, m) are not larger than from the nature of the case we might expect for independent languages. When a root common to $\mathfrak{L}'$ and $\mathfrak{L}''$ has the same *meaning* in both, it *affords a coincidence* between them. Let the roots of each language be named in arbitrary or alphabetical order $(\mathfrak{K}'_1,..\mathfrak{K}'_{a'})$, and $(\mathfrak{K}''_1,..\mathfrak{K}''_{a''})$.

"The probability that $\mathfrak{K}'_1$ be one of $(\mathfrak{K}''_1,..\mathfrak{K}''_{b''})$, is $\frac{b''}{a''}\times\frac{r}{a'}$. The probability that a given root which is in both $(\mathfrak{K}'_1,..\mathfrak{K}'_{b'})$ and $(\mathfrak{K}''_1,..\mathfrak{K}''_{b''})$ afford a *coincidence*, is $\frac{m}{a'\,a''}$, because such coincidence occurs for m of the root's $a'\,a''$ possible pairs of meanings. Hence,

$$\left.\begin{array}{l}\text{prob. of a coincidence at } \mathfrak{K}'_1, \text{ with } (\mathfrak{K}''_1,..\mathfrak{K}''_{b''}) \\ = \frac{m}{a'\,a''}\times\frac{b''\,r}{a''a'} \;=\; \frac{b''\,m\,r}{a'^2\,a''^2}\end{array}\right\} \qquad (1)$$

"Since each of the b' roots $(\mathfrak{K}'_1,..\mathfrak{K}'_{b'})$ has the chance (1_3)* of affording a coincidence, the *mean* or *probable* number of coincidences,

$$\left.\begin{array}{l}\text{prob. of 1 or more coincidence} + \text{prob. of 2 or more} + .. \\ = 1 \times \text{prob. of just 1 coincidence} + 2 \times \text{prob. of just 2} + ..\end{array}\right\} \qquad (2)$$

between $(\mathfrak{K}'_1,..\mathfrak{K}'_{b'})$ and $(\mathfrak{K}''_1,..\mathfrak{K}''_{b''})$, must be $b'\times(1_3)$, or

$$\frac{b'\,b''\,m\,r}{a'^2\,a''^2}, \qquad (3)$$

precisely; for though the number of coincidences that certain roots in $\mathfrak{L}'$ afford, will, when known, affect a little the probable number of coincidences afforded by the other roots, yet $(2_{1,2})$,* being linear, depends merely on each root's total prior probability (1_3) of giving a coincidence. Of course it is also easily deduced, that if we examine many pairs of inde-

* "By (1_3), I mean the third member of (1); by $(1_{1,3})$ or $(6_{1,2,3}, 16_4)$, each of the equal members (1_1) and (1_3), or (6_1), (6_2), (6_3), and (16_4); by (1_{13}) or $(6_{123}\,16_4)$, the equation $(1_1)=(1_3)$, or equations $(6_1)=(6_2)=(6_3)=(16_4)$; and, *temporarily*, by $(1_3)_x$, $('p_k)_x$ &c., what (1_3), $('p_k)$, &c., become when each of (a', a'', b', b'', m, r) is increased by x. By $=$, I here mean '*is nearly equal to.*'"

pendent languages for which $(a', a'', b', b'', m, r,)$ are the same, the square of the difference between the assumed and the actual number of coincidences averages least when the assumed number is (3).

"From (1_{13}),* the probability of *no* coincidence at $\mathfrak{K}'_1$ is $1 - \frac{b'' m r}{a'^2 a''^2}$; so at $\mathfrak{K}'_2$, &c.; $\therefore$ prob. of no coincidence between $(\mathfrak{K}'_1, .. \mathfrak{K}'_{b'})$ and $(\mathfrak{K}''_1, .. \mathfrak{K}''_{b''})$

$$\doteqdot (1 - \frac{b'' m r}{a'^2 a''^2})^{b'} \doteqdot e^{\frac{-b' b'' m r}{a'^2 a''^2}}* \qquad (4)$$

"To know that $(\mathfrak{K}'_1, .. \mathfrak{K}'_{b'})$ afford at least k coincidences, is to know that either $(\mathfrak{K}'\theta_{1,1}, .. \mathfrak{K}'\theta_{1,k})$ or $(\mathfrak{K}'\theta_{2,1}, .. \mathfrak{K}'\theta_{2,k})$ or &c., do so, — $(\theta_{j,1}, .. \theta_{j,k})$ being some k of the indices $(1, .. b')$; in which case k roots and k meanings, which were reckoned in (a', a'', b', b'', m, r), are already disposed of, so that if either one selection $(\mathfrak{K}'\theta_{j_0 1}, .. \mathfrak{K}'\theta_{j_0 k})$ were known to afford k coincidences with $(\mathfrak{K}''_1, .. \mathfrak{K}''_{b''})$, (4_{13}) would be changed to

prob. of no $(k+1)$ 'th coincidence, when those k are known

$$= (4_1)_{-k} \overset{*}{\doteqdot} e^{-\frac{(b'-k)(b''-k)(m-k)(r-k)}{(a'-k)^2 (a''-k)^2}} = (4_3)_{-k}; \qquad (5)$$

$\therefore$ it might seem that $(4_3)_{-k}$ was the probability of no $(k+1)$ 'th coincidence whenever we knew there were *some* k, even though ignorant *which* k. But in reality, though $\frac{(4_3)_{-k}}{1}$ of the different cases under *any one* selection $(\mathfrak{K}'\theta_{j_0 1}, .. \mathfrak{K}'\theta_{j_0 k})$ give each but k coincidences; yet, when thus *ignorant*, we must consider successively *all* the $(z = \frac{m!\ r!}{(m-k)!\ k!\ (r-k)!})$ *possible* selections made by variously choosing and assigning to each other k roots and k meanings of the r and m common to $\mathfrak{L}'$ and $\mathfrak{L}''$; and we shall thus obtain each distinct case of just k coincidences but once, each of just $(k+1)$ coincidences $\frac{k+1}{1}$ times over, each of just $(k+2)$ coincidences $\frac{(k+1)(k+2)}{1 \cdot 2}$ times, &c.; so that

$$(4_3)_{-k} \doteqdot (4_1)_{-k} = \frac{\text{prob. just } k \text{ coincidences}}{\text{prob. just } k + \frac{k+1}{1} \text{prob just } (k+1) + ..}, \qquad (6)$$

and *not* $= \frac{\text{prob. just } k \text{ coincidences}}{\text{prob. just } k + \text{prob. just } (k+1) + .. = 1}$.

"Let p_k = prob. of at least k coincidences, $\therefore p_k - p_{k+1}$ = prob. just k coincidences, between the sub-languages $(\mathfrak{K}'_1, .. \mathfrak{K}'_{b'})$ and $(\mathfrak{K}''_1, .. \mathfrak{K}''_{b''})$. Of these sub-languages there are $\lambda' \lambda'' = \frac{a'!^2}{(a'-b')!^2 b'!} \times \frac{a''!^2}{(a''-b'')!^2 b''!}$ possible pairs, formed by variously taking and assigning to one another b' [and b''] roots and as many meanings from those in $\mathfrak{L}'$ [and $\mathfrak{L}''$]. To each of the z selections, there correspond $\lambda'_{-k} \lambda''_{-k} = \frac{(a'-k)!^2}{(a'-b')!^2 (b'-k)!} \times \frac{(a''-k)!^2}{(a''-b'')!^2 (b''-k)!}$ different sub-language-pairs with k or more coincidences each; $\therefore$ nearly $(4_3)_{-k} \cdot \lambda'_{-k} \lambda''_{-k}$ with just k coincidences; and all the $z \times$ nearly $(4_3)_{-k} \lambda'_{-k} \lambda''_{-k}$ pairs thus found are distinct;

$$\therefore p_k - p_{k+1} \doteqdot \frac{z \cdot (4_3)_{-k} \lambda'_{-k} \lambda''_{-k}}{\lambda' \lambda''}$$

$$= \frac{1}{k!} \cdot (3_1)_0 .. (3_1)_{1-k} . e^{-(3_1)_{-k}} \doteqdot \frac{1}{k!} (3_1)_{\frac{1-k}{2}}^{k} \cdot e^{-(3_1)_{-k}} \qquad (7)$$

* See note on page 69.

$$\therefore p_k \doteqdot 1 - \frac{1}{0!}.(3_1)_{\frac{0}{2}}.e^{-(3_1)_0} - \ldots - \frac{1}{(k-1)!}(3_1)_{\frac{2-k}{2}}^{k-1} \; .e^{-(3_1)_{1-k}}. \qquad (8)$$

"2. Equation (4_{12}) has the copula $\doteqdot$, because our knowledge that there are no coincidences at $(\mathfrak{K}'_1, \ldots \mathfrak{K}'_i)$ slightly increases the probability q of one at $\mathfrak{K}'_{i+j<b'+1}$. But if q be a pretty continuous function of $\varpi\,(k, 0)$, $\varpi\,(k, 1)$, &c., (below), any knowledges that affect q only through them, affect q and (n = prob. number coincidences at $(\mathfrak{K}'_1, \ldots \mathfrak{K}'_i)$) almost proportionally. The knowledge of at least k such coincidences, all specified, would have changed simultaneously

$n = ('3_1)_0$ to $n \doteqdot k + ('3_1)_{-k}$, and $q = (1_3)_0$ to $q = (1_3)_{-k}$; writing $('3_1)$, $'p_k$, &c., for what (3_1), p_k, &c., become when b' is changed to i. Now $n = 0$,

$$\therefore q \doteqdot (1_3)_{('3_1)}. \qquad (9)$$

"Or thus. When we know that at least k [or just k] specified words in $(\mathfrak{K}'_1, \ldots \mathfrak{K}'_i)$ afford coincidences, let $\varphi\, k$ [or $\psi\, k$] be the probability of a certain event, or the mean value of a certain number, and let $\varpi\,(k, l)$ [or 0^l] be the probability that $(\mathfrak{K}'_1, \ldots \mathfrak{K}'_i)$ afford just $(k+l)$ coincidences. We have

$$\varpi\,(k, l) = ('p_l - '\!p_{l+1})_{-k},$$

$$\varphi\, k = \varpi\,(k, 0).\, \psi\, k + \varpi\,(k, 1).\, \psi\,(k+1) + \ldots, \quad \therefore \varphi\,(k+1) = \text{\&c.},$$

$$\therefore \psi\, k = \frac{\varphi\, k}{00} - 01.\, \frac{\varphi(k+1)}{00.\ 10} + \begin{vmatrix} 01 & 02 \\ 10 & 11 \end{vmatrix}.\, \frac{\varphi\,(k+2)}{00\ldots 20} - \begin{vmatrix} 01 & 02 & 03 \\ 10 & 11 & 12 \\ & 20 & 21 \end{vmatrix}.\, \frac{\varphi\,(k+3)}{00\ldots 30} + \ldots,$$

where hl stands for $\varpi\,(k+h, l)$. Using (l_0+1) terms we nearly allow for the others, if $\psi\,(k+l_0) \doteqdot \psi\,(k+l_0+1) \doteqdot \ldots$, by changing $\varpi\,(k+h, l_0 - h)$ to $1 - \varpi\,(k+h, 0) - \ldots - \varpi\,(k+h, l_0 - h - 1)$. When the 'event' is a coincidence at $\mathfrak{K}'_{i+j}$, $\varphi\,(k+l) = (1_3)_{-k-l}$, and (9) is reproduced by averaging the sub-indices by $('7_{14})$* and the equation

$$\begin{vmatrix} 0 & \frac{x}{1!} & \frac{x^2}{2!} & \ldots & \frac{x^{n-1}}{(n-1)!} & e^x - 1 \\ 1 & 1 & \frac{x}{1!} & \ldots & \frac{x^{n-2}}{(n-2)!} & e^x \\ 2 & 0 & 1 & \ldots & \frac{x^{n-3}}{(n-3)!} & e^x \\ \cdot & \cdot & \cdot & \ldots & \cdot & \cdot \\ n & 0 & 0 & \ldots & 0 & e^x \end{vmatrix} \doteqdot -x\,(-)^n \frac{x^{n+1}}{(n+1)!}. \qquad (10)$$

"The error of (4_{23}) is of the same order; as is seen by writing (1_3) for x, and b' for y, in

$$(1-x)^y = e^{\,y \cdot \log(1-x)} = e^{-xy\,.\,(1 + \frac{x}{2} + \ldots)} = (1 - \tfrac{xy}{2}.\, x - \ldots).e^{-xy} \qquad (11)$$

"The error of (7_{34}), being of the second order when k is small, will be neglected.

"Thus, while (1), $(2_{12}3)$, (5_{12}), (6_{23}) are already accurate; (4_{13}), (5_{14}), (6_{31}), (7_{14}), become as follows, if we retain but one order of infinitesimals,

$$(4_1) = (1-(1_3)_0)\ldots(1-(1_3)_{(b'-1)(1_3)}) = (1-(1_3)_{\frac{1}{2}(3_1)})^{b'} = (4_3)_{\frac{1}{2}(3_1)},$$

* "Or rather, in my notation of *Amer. Acad.*, 1864, by 'hl' $= \underset{\sim}{\binom{k}{l}}\,('7_{1,4})_{-k-h} \doteqdot \frac{1}{l!}\,('3_1)^l.e^{-('3_1)}$, &c."

$$\therefore (5_1) = (4_3)_{\frac{1}{2}(3_1)-k} = (6_3),$$

$$\therefore (7_1) = \frac{\varkappa\, \lambda'_{-k}\, \lambda''_{-k}}{\lambda''\ \lambda'} (4_3)_{\frac{1}{2}(3_1)-k} = \frac{1}{k!}(3_1)_{\frac{1-k}{2}}^{k} .e^{-(3_1)\frac{1}{2}(3_1)-k}. \qquad (12)$$

"When $a' = a'' = b' = b'' = m = r$,

$$(2_{1,2}) = 1,\ (7_1) \doteq \frac{1}{k!\,e},\ p_k \doteq \frac{1}{e}\left(\frac{1}{k!} + \frac{1}{(k+1)!} + ..\right).$$

"Mr. CHASE has previously shown me that if, in the expression on page 28,

$$\triangle^n 0! \times \frac{m\,..\,(m-n+1)}{n!},$$

we make n successively $= m,\ m-1,\ ..\ m-k+1$, and subtract from

$$m!\ p_0 = m!,$$

we obtain the *precise* formula,

$$\left.\begin{array}{r}
m!\ p_k = m! - \frac{m!}{e}\left(\frac{1}{0!} + \frac{1}{1!} + \frac{1}{2!} + ..\ \frac{1}{(k-1)!}\right) \\
(-)^{m}\quad \left(\frac{1}{1!} + \frac{1}{2!} + ..\ \frac{1}{(k-1)!}\right) \\
(-)^{m-1}\quad m.\ \left(\frac{1}{2!} + ..\ \frac{1}{(k-1)!}\right) \\
\cdot\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot\ \cdot \\
(-)^{m-k+2}\, m\,(m-1)..(m-k+3)\,\frac{1}{(k-1)!}. \\
(-)^{m+1}\left(\frac{1}{m+1} - \frac{1}{(m+1)(m+2)} + ..\right)\left(\frac{1}{0!} + ..\ \frac{1}{(k-1)!}\right)^{*}
\end{array}\right\} \qquad (13)$$

"3. It is known that if f be the *à priori* probability of connection between $\mathfrak{L}'$ and $\mathfrak{L}''$, whether from common origin, from common human or national tendencies to assign certain roots to certain ideas, or otherwise; and if g be the probability of at least k agreements in case of such connection, and h the probability of so many agreements in case of no such connection; then the knowledge that there are k agreements, or that there are not, changes the probability of connection to $\frac{fg}{fg + (1-f)h}$, or to $\frac{f(1-g)}{f(1-g) + (1-f)(1-h)}$.

"With much of the above, compare Dr. YOUNG'S discussion in *Phil. Trans.*, already cited."

* This term vanishes when $m = \infty$, and it may be omitted altogether, if we take the value of $\frac{m!}{e}$ to the nearest unit.

ARTICLE IV.

THOUGHTS ON THE INFLUENCE OF ETHER IN THE SOLAR SYSTEM. ITS RELATIONS TO THE ZODIACAL LIGHT, COMETS, THE SEASONS, AND PERIODICAL SHOOTING STARS.

BY ALEXANDER WILCOCKS, M.D.

Read May 20, 1864.

In undertaking the investigation of a subject whose history runs back into remote antiquity, one is met by obstacles which do not interfere with an inquiry into a more recent theme.

These difficulties lie chiefly in two of the customs of Eastern nations, viz., the mingling together of fact and fable, and the confounding of two ideas under one name.

The question might be pertinently asked, How are we concerned in what the Hindoos or the Greeks thought about ether? The answer appears practically in the fact, that the minds of some of the most eminent astronomers of the day have been biased by the views of these ancient peoples.

It is impossible for us to determine who or what first gave rise to the idea of the existence of such a fluid as ether; it was probably akin to that which avers that "Nature abhors a vacuum." If so, the conjecture, true though it be, merits no higher consideration than that of a *sublime guess*.

"Among the natural philosophers of India, ether (*âkâ'sa*) was regarded as belonging to the *pantschatâ*, or five elements, and was supposed to be a fluid of infinite subtlety, pervading the whole universe, and constituting the medium of exciting life as well as of propagating sound."

"In the dogmas of the Ionic philosophy of Anaxagoras and Empedocles, this ether (ἀιθήρ) differed wholly from the actual (denser) vapor charged (ἀήρ) which surrounds the earth, and probably extends as far as the moon." It was of a "fiery nature, a brightly beaming, pure fire air, of great subtlety and eternal serenity."

"The natural philosophy of Aristotle further teaches that the ethereal substance penetrates all the living organisms of the earth, both plants and animals; that it becomes in these the principle of vital heat, the very germ of a psychical principle, which, uninfluenced by the body, stimulates men to independent activity."*

* Cosmos, vol. iii, chap. 1.

It is scarcely necessary to remark that the ether by whose agency it is proposed to explain the interesting phenomena alluded to in the title of this essay, is not a fluid possessed of the fanciful properties ascribed to it by the ancients. My only purpose in dwelling upon these is to show, as I shall do presently, how such ideas have poisoned the minds of modern philosophers.

To Professor Encke is the learned world indebted, for pointing out the first rational evidence of the existence of an ethereal medium, in the continually diminishing period of the comet which bears his name.

By its influence upon Encke's comet, the ether shows itself to be possessed of two of the properties of aeriform bodies, viz., inertia and impenetrability. It would not be advancing too far, nor too fast into the land of speculation, to endow this fluid also with gravity, elasticity, and expansibility by heat.

The possession of the properties of gravity and elasticity leads to the conclusion that the particles of ether must be collected into denser masses in the vicinity of the central body of our system, than in regions remote from the sun; and the inquiry at once suggests itself, what law governs the density of the ether in the different parts of the solar system?

In the terrestrial atmosphere, where the influence of a varying distance from the centre of attraction is too small to be appreciated, and where the increase of the density near the earth's surface is due almost solely to the superposition of the particles of air, we find the rate of diminution of density to be in the duplicate ratio of the altitude.

In the interplanetary spaces, the laws which determine the rate of diminution of the density of the ether are more complicated.

The ethereal pressure at any given point in the solar system, will depend not only upon the *quantity* of ether beyond it, but also upon the *power* which the *sun* has to attract that which is beyond the point in question.

Now, either of these causes acting alone should fix the rate of diminution at the square of the distance from the sun. As both of them act together, a legitimate inference should be, that the density of the ether decreases as the fourth power of the distance from the sun's centre.

In considering the subject of ether, we must endeavor to guard ourselves against certain errors into which our daily intercourse with matter may lead us. We see, for example, the collision of heavy bodies, and, as a result, the production of fragments whose weight and hardness we can estimate with our hands. These are phenomena which so vividly impress our senses, that we are apt to ignore the possible existence of matter in a form which, to our sight and touch, may be inappreciable.

It is this form of matter that now concerns us, and to give a faint idea of its tenuity,

let me say that physicists have estimated that beyond the region of our atmosphere there is no matter as dense as the contents of an exhausted receiver.

While engaged upon this subject, let us put aside the gross ideas which attach to matter upon the surface of our planet, let us view it as we know it exists in the celestial spaces, and let us be prepared to find in the movements of the ether when impelled by the tremendous energies which I shall presently invoke, a rapidity, which knows no parallel among the ponderable agents with which our senses bring us into contact.

We must now study some of the facts which the observations of eminent astronomers have taught us, concerning the governing orb of our system.

The sun is known to have an opaque nucleus, surrounded by an atmosphere of vast but unknown height, one stratum of which is luminous, and has received the name of *photosphere*. Certain appearances resembling luminous clouds, seen round the disc of the moon during the time of a total eclipse of the sun, lead to the belief that the sun's atmosphere extends far above the luminous stratum. In that elevated region of the sun's gaseous envelope, there are strong indications of imperfect transparency.

A close examination of the spots upon the sun's disc, teaches us that it revolves upon an axis, which is inclined to the plane of the ecliptic.

The determination of the period of the sun's rotation, with the amount and direction of the inclination of its axis, is among the difficult problems of astronomy. Different results have been obtained by different observers. I shall rely upon the accuracy of those furnished by M. Arago for these data, which are of vital importance to the theory I am about to offer.

According to the authority cited, the sun's axial rotation is accomplished in 25.5 days. The solar equator is inclined to the ecliptic about 7 degrees; and the line of nodes is in longitudes 75° and 255°.* Let me add that the north pole of the sun is inclined toward longitude 345°.

An interesting feature in the sun's constitution, the study of which has occupied the minds of Henry, Nervander, Carlini, Secchi, and others, is the difference in temperature of different parts of the solar surface. The observations of Secchi have produced more definite results than those of his colaborers in this field of research.

Secchi made observations upon the sun on the 20th, 21st, and 22d March, 1852, which were unsatisfactory in several particulars. At that time of the year the sun's equator appears at its extreme angular distance from the plane of the ecliptic. The observations were continued only three days, when twenty-seven were requisite for valuable results; and instead of being made in the line of the sun's axis, the line of a circle of declination was chosen, which on the 21st March lies at an angle of 25° 15′ 57″ with the former.

* Astronomie Populaire, vol. ii, pp. 86 and 87.

Secchi was more happy in the choice of a time for observing the sun's temperature in the year 1855.* The 8th of June was fixed upon, as the sun is then near that part of the heavens where the plane of its equator intersects the ecliptic.

The latter observations were undertaken with the view of determining the effect of the sun's atmosphere in diminishing the power of its rays. They produced no new facts in the matter of the relative temperature of different parts of the solar surface.

From an analysis of Secchi's observations on the sun in 1852, M. Arago presents the following summary: Different points of the sun's surface have different temperatures. The rays from the centre of the disc produce most heat, and from that point the heat diminishes towards the margin. At equal distances from the centre of the disc, the polar regions have a lower temperature than those about the equator; and the two hemispheres separated by the equator have unequal temperatures. The spots produce a diminished temperature, but the faculæ do not cause a sensible increase of heat.†

From Secchi's observations in 1852, Prof. Littrow concludes that the intensity of radiation of heat of different points in the sun's disc is different, not only in consequence of the absorption by the sun's atmosphere, but also because every part of the sun's surface really has its peculiar temperature. On the 20th, 21st, and 22d March, the greatest intensity was found 3′ north of the sun's centre. The sun's equator was at the time 2.6′ north of the centre. The northern and southern hemispheres have unequal temperatures, as well as the hemispheres, divided by a heliocentric circle of declination.‡

Having collated the data relating to the rotation of the sun, the position of its axis, and the heat of its surface; having also drawn such conclusions regarding the density and other properties of the ether as observation and analogy have appeared to sanction, let us endeavor to determine what conditions are induced by the sun in the great ethereal ocean of which it is the centre.

A ponderable elastic fluid of imperfect transparency, resting upon the surface of an incandescent sphere, could not by any possibility remain in a state of rest.

If the sphere were at rest, and its whole surface of a uniform temperature, there should be upon every part of it alternate ascending and descending currents of the elastic medium; but, if any zone were permanently of a higher temperature than the rest of the surface, then ascending currents should be permanently established upon such part of the sphere, and descending currents upon those portions where the temperature was of a lower grade.

We have learned that the parts of the sun's surface which have the highest temperature, are the equatorial regions, and that those having the lowest are the polar regions;

* Astronomische Nachrichten, No. 1230.

† Astronomie Populaire, vol. ii, p. 173.

‡ Wunder des Himmels, appendix, p. 818.

we are, therefore, led to the conclusions, that from the equatorial zone there is a permanent ascending current of ether, and that upon the two polar regions there are descending currents.

If the sun's surface *had* a uniform temperature, its axial rotation should bring about the same conditions as those I have shown to result from the peculiar distribution of its heat. The fluid resting upon the revolving sphere, its lowest stratum should partake of the motion of the sphere. The centrifugal force resulting from the circular motion should cause an accumulation of fluid upon the equatorial zone, and as a result a rarefied condition of the fluid in those parts where the causes of the excess existed in the *smallest* degree. The centrifugal force is null at the poles; therefore, upon the polar regions should be thrown the supply of cold fluid to preserve the equilibrium.

As particles of fluid moving from opposite points towards a centre, always take the direction of a circle round that centre, we are led to the belief that the ether descends upon the polar regions in the form of vortices.

Thus do we find in the constitution of the sun, two distinct causes, the one depending on heat, the other on motion, which produce in the ethereal medium a double circulation over the solar surface, and through the region of the planets.

Let us trace the course of these stupendous currents. Towards the poles of the sun, as the seats of the lowest heat and the least motion, the ether is drawn from the regions of space, and descends upon the poles and the adjacent parts in the vortical form. Thence it is wafted by the double set of causes towards the equator, whence it is forced out into the region of the planets, in a mass whose form closely resembles a perfectly flat plate, the plane of which nearly coincides with that of the sun's equator.

With regard to the energy with which these movements in the ether are effected, our approaches to a conjecture must be based upon a comparison between the causes which produce currents in the earth's atmosphere, and those brought into play in the grand ethereal circulation.

In carrying out this parallel, we must fix our attention successively upon each of the causes known to be concerned in the production of motion in the terrestrial atmosphere, and then upon the corresponding one, believed to influence the movement of the ether.

By collating the results of these several comparisons, we may obtain the basis for a conjecture as to the velocity of the ethereal currents.

The immediate cause of all motion in our atmosphere is the earth's gravitating power, and by an analogous influence the sun occasions the ethereal circulation. The sun's energy in this respect is *cæteris paribus* directly as its mass. The mass of the sun is 354,936* times that of the earth. Here we have the first element of our comparison.

* Herschel.

The next point to be considered is the difference of heat in different parts of the earth, in comparison with the temperature of space contrasted with that of the sun's surface.

The heat of the sun's surface is estimated at 300,000 times that produced by its rays upon the surface of our planet. If we assume the minimum temperature of our atmosphere to be the same as that of space, we should have the measure of the sun's power to expand the ether, as compared with the influence of its rays upon our atmosphere, at 300,000.

This is the second element of our comparison.

The last I shall offer is the difference between the height of the earth's atmosphere, and the depth of the ethereal ocean.

The earth's atmosphere is supposed to extend to the distance of from 40 to 200 miles above its surface. We have no reason to suppose the ether has a limit within that of the solar system.

If the velocity of the ether depend upon these agencies, it certainly defies computation. But we may safely believe that it surpasses that of all known ponderable fluids; and can be likened, in the vicinity of the sun, only to that of light.

When an image of the sun is thrown upon a sheet of white paper, it may be observed that the borders of the disc are much less luminous than the centre. This may be explained by the *refractive* or the *absorptive* power of the sun's atmosphere.

When, during an eclipse of the sun, the moon is centrally over the former, a ring or corona of light is seen fading gradually away. This phenomenon cannot be explained without admitting in the sun's atmosphere the existence of some matter capable of reflecting light.

Various hypotheses have been offered as to the origin of this reflecting matter. Its existence alone concerns us; without it, a link in the chain of reasoning would be wanting, which would defeat our aims; for unless the ether contained matter which could arrest the sun's rays, it would be impossible to establish by *à priori* reasoning, the existence of currents.*

A mass of ether ascending from the equatorial region of the sun, and containing matter capable of reflecting light, should certainly make an impression upon our visual organs, whenever the absence of the sun favored its being seen. It therefore becomes a question of much interest, what form should be given by perspective to such an object, as seen from the earth.

The approximate form which I have deduced for the ascending current of ether, is that

* It will be observed that I have used the terms ether and sun's atmosphere, almost as synonymes. Until we learn in what the constitutions of these fluids differ, or where is the dividing line between them, the confounding of their names can produce no evil results.

of a flat plate, whose plane coincides with the sun's equator. But inasmuch as the maximum heat upon the sun's surface was found a little north of the equator, the form of the ascending current of ether should be rather that of *a hollow, frustated cone,* whose sides, if produced, would form an exceedingly obtuse angle at the sun's centre.

If we suppose that the functions of receiving cold ether from the regions of space, and of forcing it again from the sun, divide the surface of that orb into equal parts, the zone from which the current ascends must have a breadth of 30° on each side of the sun's equator. Such a division of the solar surface is, however, inadmissible, for the ether descending upon the poles should have its volume so enormously increased by the sun's heat, that the area from which it escaped into space, must have a great preponderance over the regions where the fluid arrives in its condensed state. We may, therefore, conclude that the regions upon which the ether descends are comparatively small.

The ether which ascends from the regions remote from the equator, must have initial directions deviating much from the plane of that circle; this should make the thickness of the ascending current, near its origin, as great, or greater than the diameter of the sun.

But this thickness we cannot suppose could continue; for, as the ether advances into the region of the planets, its expansion should be counterbalanced by a loss of thickness. The immediate cause of the flattening being the pressure of the cold ether on the two sides of the plate.

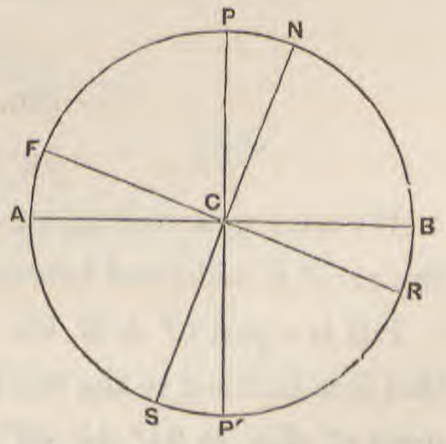
With the flattening of the ascending current, we may look for the effect of the position of the line of maximum heat upon the sun's surface.

An analysis of Secchi's observations leads to the conclusion that the line of greatest heat is at the distance of 1° 29′ 06″ north of the sun's equator.*

* The purpose of the following demonstrations is threefold. Firstly, to show the relations which the axis and equator of the sun bear to the ecliptic. Secondly, to picture the appearance which the sun presented to Secchi at the time of his observations. Lastly, by trigonometrical measurement to determine, with Secchi's observations as data, the position of the line of maximum heat upon the sun's surface, with reference to the solar equator.

Fig. 1 is designed to show the positions of the equator and axis of the sun in relation to the ecliptic. A B represents the plane of the ecliptic, P P′ its poles. The circle is the sun's disc, F R its equator, and N S its axis.

FIG. I.



The time of the year when the parts appear in these relations, is about the 6th of June. N C P is the angle by which the sun's axis is inclined to the poles of the ecliptic, about 7°.

As the earth revolves in its orbit, the sun's axis apparently describes a circle about the poles of the ecliptic.

All this will appear more clear by viewing the solar system from a point in space opposite its northern face.

In Fig. 2, the smaller circle represents the sun; the larger one the earth's orbit. E is the earth, on the 21st March. P is the pole of the ecliptic, N the north pole of the sun, inclining towards longitude 345°. If the

If the form of the mass of heated ether be determined by the causes I have cited, it

earth were at D, the parts would appear as described in figure 1. If the earth were at F (the position occupied by our planet about the 5th of March), the sun's axis and the poles of the ecliptic would appear to coincide, but the earth being at E, they deviate by O N, which is the sine of an arc of 15° whose radius is 7°.

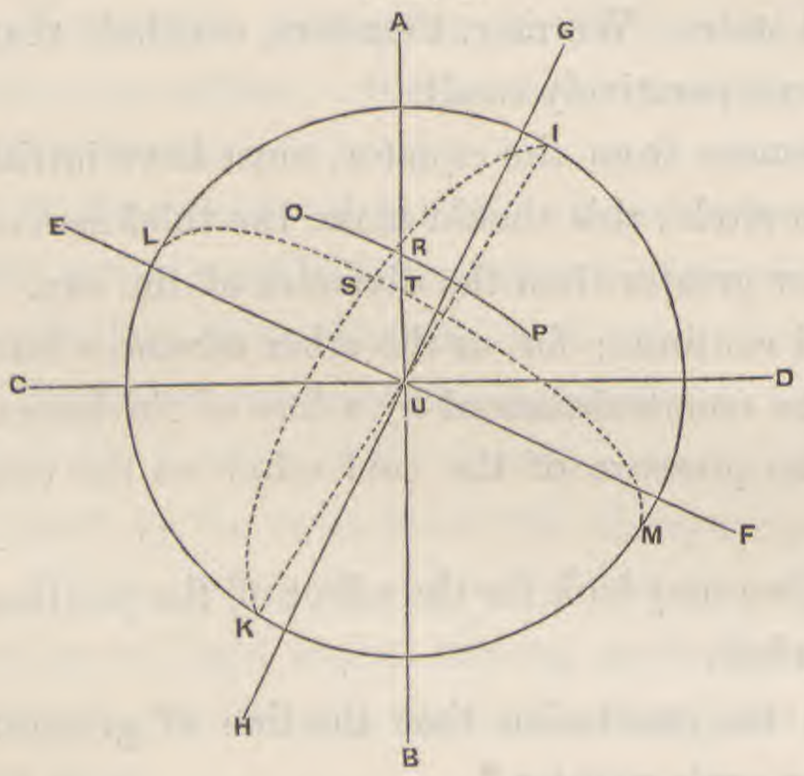
Let us ascertain the value of this deviation in degrees of the sun's surface.

Radius : Sin. 15° : : Sin. 7° : Sin. 1° 48′ 27″.

We are now prepared to picture to ourselves the sun as it appeared to Secchi on the 21st March, 1852. We have ascertained that the apparent inclination of its axis to the poles of the ecliptic, was 1° 48′ 27″, and we have the data for determining the relations of all its parts to the great circles which are the landmarks of astronomy.

In Fig. 3, the circle represents the sun's disc. The line A B is a circle of declination, C D is the equinoctial line. E F is the ecliptic. G H, the poles of the ecliptic. I K, the sun's axis. L S T M, its equator, and O R P, the line of maximum heat, which Secchi observed on the 20th, 21st, and 22d March.

FIG. 3.



My purpose is to ascertain the measure of an arc of the sun's surface R S, embraced between the equator and the line of maximum heat.

On the 21st March, the angle A U G, or that embraced between a circle of declination and the poles of the ecliptic, is 23° 27′ 30″.

We have ascertained that the angle G U I, or the apparent deviation of the sun's axis from the poles of the ecliptic on the day named, was 1° 48′ 27″. By adding these together, we shall have 25° 15′ 57″, or the angle embraced between the sun's axis and a circle of declination.

Secchi informs us that when he made his observations, the sun's equator was 2.6′ north of the centre of the disc. In Fig. 3, this is represented by U T. He found the point of maximum heat to be 3′ north of the centre of the disc, U R in the figure.

On the 21st March, the sun's semi-diameter is 16′ 4.6″. This is the radius of the arcs of which Secchi has furnished us with the sines.

In our investigation we require the measures of these arcs, and their difference in degrees of the sun's surface.

Arc U T.

Sin. 16′ 4.6″ : Sin. 2′ 36″ : : Radius : Sin. 9° 7′ 51″.

Arc U R.

Sin. 16′ 4.6″ : 3′ : : Radius : Sin. 10° 45′ 23″.

10° 45′ 23″—9° 7′ 51″ = 1° 38′ 32″.

We have now ascertained the measure of the arc T R, which will enable us to attain our end; the measure of the arc S R embraced between the sun's equator and the line of maximum heat.

T R is a part of A B, the circle of declination in which Secchi made his observations. We have ascertained that it is inclined to the sun's axis 25° 15′ 57″. The angle which it forms with the solar equator is the complement of this, or 64° 44′ 03″. The last is the measure of the angle R T S.

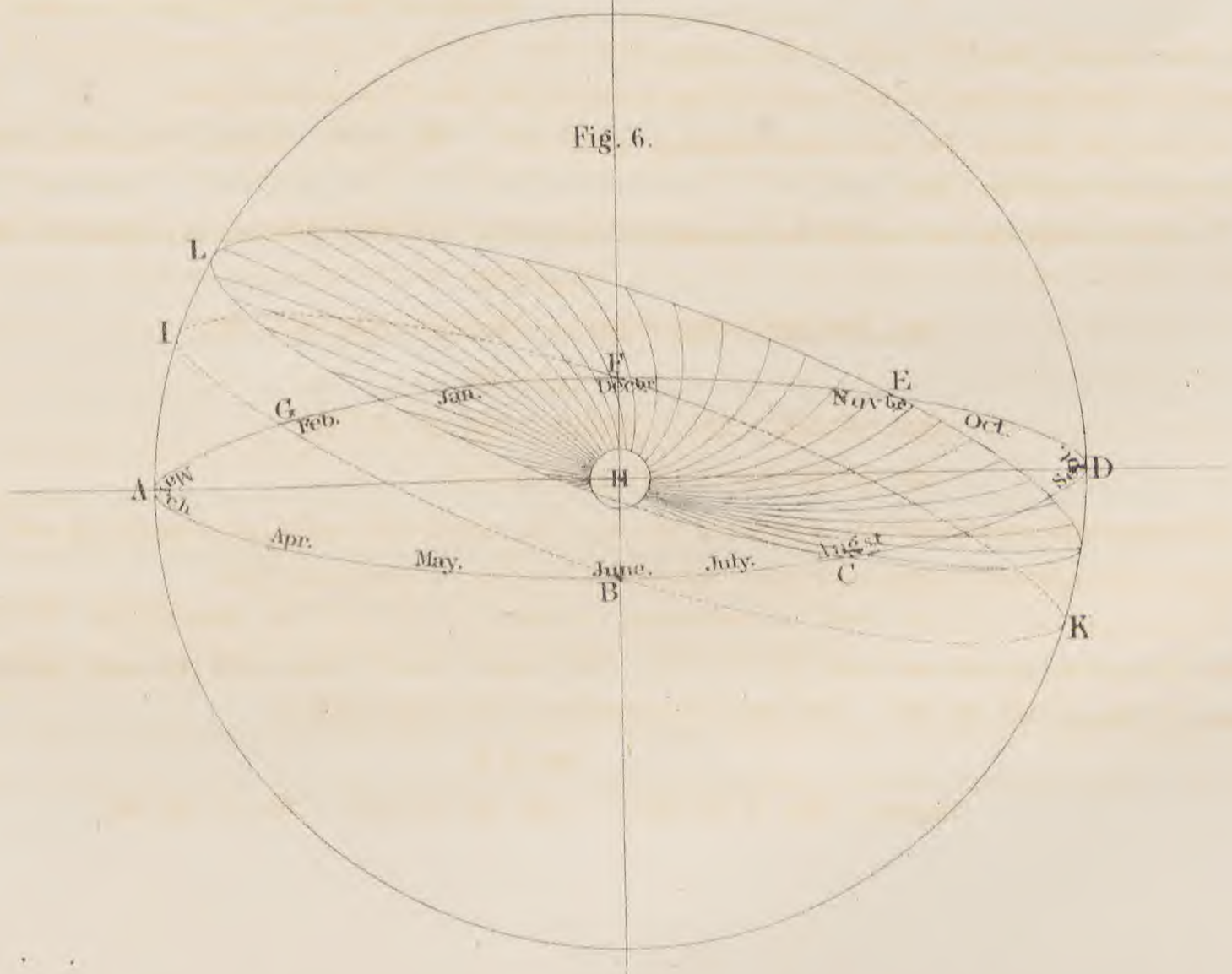
Arc S R.

Radius : Sin. 1° 38′ 32″ : : Sin. 64° 44′ 03″ : Sin. 1° 29′ 06″.

Fig. 2.


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Fig. 6.


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justifies the description already given to it, viz., a huge plate, whose sides incline a little from the plane of the sun's equator, so as to give it the character of a hollow cone; the sun's centre occupying the apex of the cone.

Now, how should such a figure appear to an inhabitant of our planet? The earth can never be much removed from the plane of the sun's equator, nor from the body of this mass of heated ether. The mass being seen very obliquely, should have the appearance of a great spindle, whose long axis lies a little north of the plane of the sun's equator. If the current of ether carry reflecting matter as far as, or beyond the orbit of the earth, the spindle should extend 90° or more from the sun.

As the earth's orbit is most distant from the plane of the sun's equator, at the points passed by the planet in March and September, the spindle should, at those seasons, have the greatest breadth. More particularly in March, because the earth is then to the south, and the mass to the north of the plane of the sun's equator. While in September the mass is between the earth and the plane of the sun's equator.*

It is not possible to allow our thoughts to pursue this train, without finding that our minds rest upon the *Zodiacal light* as the evidence of the truth of our reflections.

The zodiacal light in our latitude is seen after sunset in the months of March, April, and May, and before sunrise during the opposite season of the year. It extends along the zodiac, and accompanies the sun in its annual course through the heavens.

It has the form of an ellipse or elongated spindle. The dimensions of the light are variable, its long axis, which coincides nearly with the plane of the sun's equator, extending, according to different observers, from forty to one hundred degrees from the sun. The breadth of its base varies from eight to thirty degrees. It does not efface the light of the smallest stars.

Cassini, one of the earliest observers of the phenomenon, thought the mass of light was not divided equally by the ecliptic; the greater portion being to the north of that great circle. This fact has been confirmed by the observations of Fatio de Duillier, made at Geneva, in 1685 and 1686.†

From observations made at Paris and Geneva, it is established that the zodiacal light has not always the same intensity; it varies from year to year, and even within the limits of a few days.

Among the speculations into the cause of the zodiacal light by the astronomers of the seventeenth and eighteenth centuries, we find very discordant views entertained by the same individuals.

J. D. Cassini conceived that the zodiacal light was a nebulous ring surrounding the sun. He believed that the ring contained small planetary bodies.‡ He admitted at another

* See Fig. 6. † Astronomie Populaire, vol. ii, p. 186. ‡ Cosmos, vol. i, p. 141.

time that the sun might dart matter in the plane of its equator, as far as the orbit of Venus; and that the light reflected from this matter was the cause of the phenomenon.

He suspected, too, that there was a sympathy between the appearance of spots upon the sun's surface and the changes in the zodiacal light.*

Euler was of opinion that the matter which produced the zodiacal light did not extend to the sun, but surrounded it at a certain distance, in the form of a ring.† He is also the author of an essay in the Memoires of the Academy of Berlin,‡ in which the phenomenon is ascribed to the prodigious extension of the sun's atmosphere in the equatorial region; this extension being caused by the impulsion of the solar rays.

M. Arago remarks, it is really strange that so decided a partisan of the undulatory theory of light, so ardent an opponent of the Newtonian doctrine of emission, should give so active a role to the impellent power of the sun's rays.§

The ring hypothesis has been adopted by Schubert, Poisson, and Humboldt; the last considers that the ring is much compressed, and lies between the orbits of Venus and Mars.‖

Olbers believed that the matter composing the zodiacal light extends all the way to the sun, and that the light seen round that body during a total eclipse, is caused by the portion of the matter in that vicinity.¶

These views of Olbers are entirely consistent with the conditions I have been endeavoring to establish; they would have been more interesting, had he advanced some theory to sustain the matter of the zodiacal light in the position which he supposed it to occupy.

La Place entertained views upon the subject of the zodiacal light which were a part of his grand scheme known as the *Nebular hypothesis*. He believed that after the denser parts of the nebula had been consolidated into the sun and planets, there remained a subtile portion, whose atoms revolved round the sun with velocities proportioned to their distances.**

Dr. Young supposed that the phenomenon was caused by the refraction of the sun's light in the earth's atmosphere. But M. Arago asks, why, if this be the cause, should the light be oblique to the horizon.

One of the most modern hypotheses upon this subject, is that of our countryman, the late Professor Olmstead, of Yale College. He conceived that a nebulous body revolves round the sun in an orbit of considerable excentricity, and in a period of six months. The aphelion distance of the nebula he supposed to be equal to the radius of the earth's orbit. On the 13th November he believed the earth and the nebula to pass that point,

* Astronomie Populaire, vol. ii, p. 188.
† Op. citat., vol. ii, p. 183.
‡ Vol. ii, 1748.
§ Astronomie Populaire, vol. ii, p. 190.
‖ Cosmos, vol. i, p. 141.
¶ Ib., vol. i, p. 143.
** Astronomie Populaire, vol. ii, p. 191.

and to remain in proximity to each other about eight hours. By this scheme Professor Olmstead undertook to account not only for the phenomenon under consideration, but also for the shooting stars of the 13th November.* This hypothesis has been adopted by M. Biot.

Another hypothesis of American origin, is that of the Rev. George Jones, Chaplain U. S. Navy. This gentleman, during a voyage to Japan, in the frigate Mississippi, had ample opportunities to examine the zodiacal light between the tropics. Observing that the phenomenon was visible until midnight, not only in the west, but also in the east, he drew the conclusion that the earth was surrounded by a nebulous ring within the orbit of the moon. He also holds the opinion that the moon, by her light, occasionally produces the zodiacal phenomenon.†

Let us examine critically into the competency of some of these hypotheses to explain the cause of the zodiacal light.

In this attempt we must be guided in a great measure by the laws of perspective, which, from the antiquity of the arts of designing and painting, are more thoroughly explored and practically understood than those of almost any other science.

The conjecture most in vogue to explain this phenomenon, is that of a nebulous ring between the orbits of Venus and Mars. Such a ring must be either *equidistant* from the sun with the earth's orbit, *within*, or *beyond* it.

Let us suppose first, that it is *equidistant* with the earth's orbit, that our planet moves through the heart of the ring, as a string is passed through a circle of beads.

Our observer shall be stationed upon the equator at sunset, on the 21st March. If he should raise his eyes towards the zenith, and fix them upon a point 23° 28′ north of the same, he would be looking towards that part of space which the earth had just left. He would, therefore, look into the substance of the ring. The reflection of the sun's light should cause a visible brightness in that part of the heavens, which should fade towards the horizon; besides which, there should be a prolongation of light extending from the point in question towards the western horizon, decreasing in width, but not in brilliancy, to the latter. The cause of this prolongation of light would be the part of the ring occupying the quadrant of the earth's orbit which had been last passed over.

As the night passed on, our observer would find that the brilliant spot near his zenith was sinking towards the west, and at midnight had set. If at this moment he should turn his eyes to the east, he would discover a similar bright spot rising; he would then be looking again into the substance of the ring, but towards the opposite point of space, that, in fact, towards which the earth was moving. As this spot rose towards the zenith, he would

* American Journal of Science and Art, vol. xxix, p. 376.

† Astronomical Journal, Cambridge, Mass., No. 84, May 26, 1855.

discover another prolongation of light extending to the eastern horizon, and caused by the part of the ring lying in the quadrant of the earth's orbit, through which it was about to pass. The bright spot would finally reach a point 23° 28′ south of the zenith, when the sun would rise.

These are appearances which must of necessity ensue in the existence of the conditions above proposed. They never having been observed, proves that the conditions do not exist. There is no ring equidistant with the earth from the sun, and through which our planet moves.

Let us next suppose that the nebulous ring is *within* the earth's orbit, and to carry out the scheme of those who favor the hypothesis, let the plane of the ring coincide with the sun's equator. A ring so placed could never appear to extend ninety degrees from the sun, which distance the zodiacal light often exceeds. Further, in the months of March and September, when the earth is at its maximum distance from the plane of the sun's equator, a dark triangular space should be seen between the ring and the sun, especially if, as Von Humboldt surmises, the ring is much compressed.

So far from such an appearance being observed, the portion of the zodiacal light near the sun is the brightest. These two objections are sufficient to dispose of this conjecture.

The last branch of the ring hypothesis is, that the ring is *beyond* the earth's orbit. In this case the brightness should extend from the point of the horizon where the sun had disappeared, through all the visible signs of the zodiac to the eastern horizon. The part having the greatest brightness should be nearest the zenith at midnight, because the particles of the ring in that position would be in the category of full moons, presenting the whole of their illuminated surfaces to the earth.

Has such an appearance ever been seen? If not, the conditions which should occasion it do not exist.

With regard to Cassini's idea of the sun's power to *dart* matter into space in the plane of its equator, do not let it be confounded with the theory I am endeavoring to establish, of the ascent of a current of ether in the equatorial region, from the cause of its lessened specific gravity.

The sun's power to dart matter into space, is purely conjectural.

With the limited amount of our knowledge of nebulæ, it would be an ungrateful task to argue either for or against the competency of Professor Olmstead's hypothesis, to explain the cause of the zodiacal light. Were this point conceded, there are other objections to it which should render its adoption by reasoning people an impossibility.

The existence of the nebulous body, of which he furnishes us not only with the periodic time, but also with the perihelion and aphelion distances, is an idea for the truth of which there is not a shadow of evidence.

The doctrine of probabilities satisfies me that if a nebulous body did revolve round the sun in the space within the earth's orbit, the chances of its performing its revolutions in exactly half a year, and meeting the earth annually on the 13th of November, would be precisely one to infinity.

It is true the arcana of astronomy furnish us with some remarkable coincidences, not only in the simple periods, but also in the grand cycles of the heavenly bodies. I shall have occasion in the progress of this essay to point out one of these coincidences not heretofore noticed, having an important bearing upon our subject, and which, in respect of exactitude, is almost without a parallel in the annals of the science. But any hypothesis, based upon an *imaginary* coincidence in period of bodies independent of each other, staggers under a load which will certainly crush it.

We have one more hypothesis to examine, that of the nebulous ring round the earth, proposed by the Rev. George Jones, U. S. N. If an unprejudiced person, one who had the ability to reason in such matters, were asked what effect the sun's rays should have upon a ring so placed, his reply would be, that matter placed in a circle round the earth should have, in all its parts, optical relations, identical with those of the moon when occupying corresponding positions. Thus, the part of the ring in opposition to the sun, should shine with the greatest brightness; the parts in quadrature with the sun, with half the brightness, &c. The brightest part should be nearest the zenith at midnight. The reverend gentleman makes no mention of such an appearance. His observations, therefore, do not conform to the requirements of his hypothesis.

Von Humboldt, in commenting upon the Rev. George Jones's paper, says he has observed the same phenomenon, *i. e.*, the zodiacal light in the east, as well as in the west, after sunset. He noticed that the two lights disappeared at the same time, and ascribed the cause of the phenomenon in the east to reflection.*

I would fain believe that the objections I have urged to the hypotheses hitherto offered, to explain the cause of this interesting phenomenon, do not apply to the theory here deduced from independent data.

The form and position which the laws of perspective give to the ascending mass of ether, conform to those which observation has given to the zodiacal light, even to the minute point of the greater portion being north of the ecliptic.

The changes in the velocity, &c., of the many minor currents which make up the great hollow cone, depending as they must, upon the varying conditions of the sun's surface, explain the changes which the zodiacal light presents from day to day.

* Comptes Rendus, October 22, 1855.

ETHER. ITS RELATIONS TO COMETS.

After the decline of the Peripatetic school of philosophy, few of the grand operations of nature were ascribed to the agency of ether. The chief additions to its role prior to the present century, were made by Huyghens and Sir Isaac Newton; the former giving to ether a no less important function than the transmission of light, and the latter explaining by its action, one of the phenomena of comets, still held by most astronomers to be a profound mystery of nature.

The views of Sir Isaac Newton on the influence of ether upon the tails of comets, may be found in Book iii, Prop. xli, of the Principia. They accord with the theory I am endeavoring to explain, and are not the less interesting because of his failure to impress the truth of his views upon the scientific world. He says, "Kepler ascribes the ascent of the tails of the comets to the atmospheres of their heads; and the direction towards the parts opposite to the sun, to the action of the rays of light, carrying along with them the matter of the comets' tails; and, without any great incongruity, we may suppose that in so free spaces, so fine a matter as that of the ether may yield to the action of the rays of the sun's light, though those rays are not able sensibly to move the gross substances in our parts, which are clogged with so palpable a resistance."

"Another author thinks that there may be a sort of particles of matter endowed with a principle of levity, as well as others are with a power of gravity; and that the matter of the tails of comets may be of the former sort, and that its ascent from the sun may be owing to its levity; but, considering that the gravity of terrestrial bodies is as the matter of the bodies, and therefore can be neither more nor less in the same quantity of matter, *I am inclined to believe, that this ascent may rather proceed from the rarefaction of the matter of the comets' tails.*"

"The ascent of smoke in a chimney is owing to the impulse of the air with which it is entangled. The air rarefied by heat ascends, because its specific gravity is diminished, and in its ascent carries along with it the smoke with which it is engaged; and why may not the tail of a comet rise from the sun after the same manner? For the sun's rays do not act upon the mediums which they pervade, otherwise than by reflection and refraction; and those reflecting particles heated by this action, heat the matter of the ether, which is involved with them. This matter is rarefied by the heat which it acquires, and because by this rarefaction the specific gravity with which it tended towards the sun before, is diminished, it will ascend therefrom, and carry along with it the reflecting particles of which the tail of the comet is composed."

I have made this quotation from the Principia, because I find that M. Arago, from a

too partial, has given an incorrect version of Sir Isaac Newton's views upon the subject of comets' tails.*

We may easily pardon in the author of the *corpuscular theory of light*, his qualified indorsement of Kepler's theory of comets' tails. The true views of Newton upon this subject were undoubtedly those described in the last part of the quotation from the Principia.

It is certainly a subject entitled to consideration, why so ingenious and plausible a theory should have met with such slender success. There are probably several reasons. Firstly, the existence of any fluid in the interplanetary spaces, was all conjecture. Secondly, those men who believed in the existence of an ether, had their minds so imbued with the notions of the ancients upon the subject, that they could not admit its being possessed of sufficient materiality to direct the tail of a comet. Lastly, the minds of the astronomers of the present century have probably been confirmed in their opposition to the Newtonian theory, by the appearance of the comet of 1823, and of others, with their tails directed towards the sun.

My own belief is, that the usual direction of the tails of comets is occasioned by a cause similar to that which gives to the flame of a candle a direction away from the earth, viz., that the specific gravity of the matter of the tail is less than that of the surrounding ether, and thus, by external pressure, the heated mass is forced away from the centre of attraction.

I hope, by the aid of discoveries made since Newton's day, to explain satisfactorily the cause of a different direction in the few exceptional cases which have been observed.

The next phenomenon of comets I have to mention, which has been ascribed to the influence of ether, is the one upon which this essay is founded,—the discovery of Professor Encke.

"On comparing the intervals between the successive perihelion passages of Encke's comet, after allowing, in the most careful and exact manner, for all the disturbances due to the action of the planets, a very singular fact has come to light, viz., that the periods are continually diminishing, or, in other words, the mean distance from the sun, or the major axis of the ellipse, dwindling by slow and regular degrees, at the rate of about 0.11 days per revolution. This is evidently the effect which would be produced by resistance experienced by the comet from a very rare ethereal medium pervading the regions in which it moves; for such resistance, by diminishing its actual velocity, would diminish also its centrifugal force, and thus give the sun more power to draw it nearer. Accordingly, this is the solution proposed by Encke, and at present generally received."†

This point in the history of comets is of more importance than any other connected with the subject, as all deductions concerning the existence of ether are based upon it.

* Astronomie Populaire, vol. ii, p. 411.

† Herschel's Outlines, chapter xi.

Another phenomenon of comets, which has exercised the ingenuity of astronomers, and one for which an explanation has been sought in ethereal influence, is the fact that, as they approach the sun, their bulk becomes diminished, and increases after passing the perihelion.

If comets were elastic bodies, expansible by heat, and not exposed to any varying pressure, these phenomena are the reverse of what *à priori* reasoning should lead us to expect.

The explanation referred to is the result of the labors of M. Valz, whose theory is thus noticed by M. Arago.

"To explain these changes of volume, M. Valz supposes that the ethereal substance forms round the sun a true atmosphere, that, as in the terrestrial envelope, the lower strata are condensed in proportion to the quantity of the superincumbent medium. He believes that in passing through these regions, the comet must be exposed to a pressure proportioned to the density of the strata. There would be no difficulty here, if we could admit that the exterior envelope of the nebulosity was not permeable to the ether supposed to pervade the universe."

"Everybody knows that a bladder filled with air at the base of a mountain, swells if it be transported towards the summit, and that it will burst if it be taken to a sufficient height. But, where shall we find the pellicle to assimilate the nebulosity to a bladder, which would prevent the ether from penetrating it in every direction, and invading its smallest ramifications?"

"This difficulty for the present seems insurmountable, and we deeply regret it, for the ingenious hypothesis of M. Valz has furnished him with the law of the variations in volume of the nebulosity, as well for the comet of short period, as for that of 1618, with an exactitude truly extraordinary."*

Sir John Herschel makes the following remarks upon the proposed explanation:

"M. Valz, who was the first to notice this fact (in Encke's comet), accounts for it by supposing it to undergo a real compression or condensation of volume, arising from the pressure of an ethereal medium, which he conceives to grow more dense in the sun's neighborhood. But such a hypothesis is evidently inadmissible, since it would require us to assume the exterior of the comet to be in the nature of a skin or bag impervious to the compressing medium."

"The phenomenon is analogous to the increase of dimension above described, as observed in the comet of Halley, when in the act of receding from the sun, and is doubtless referable to a similar cause, viz., the alternate conversion of evaporable matter into the states of visible cloud, and invisible gas, by the alternate action of cold and heat."†

Is not this a melancholy confession for men of the standing of M. Arago and Sir John

* Astronomie Populaire, vol. ii, p. 391.

† Outlines of Astronomy, chapter xi.

Herschel? The observations, the calculations, the successful result of the labors of M. Valz to be put aside, because they, though living in the nineteenth century, were, in the matter of ether, wedded to the doctrine of the ancients. *The comet would want a skin.* Most justly did Bacon classify among the causes of error the *Idols of the Theatre.*

Let me endeavor to draw a parallel which may shed some light upon this cometary phenomenon. Suppose a given bulk of our atmosphere, containing a cloud, to be brought from the region of the cumuli to the surface of the earth. Now a cloud like a comet has no skin; yet, does any one doubt that (neglecting the changes produced by heat) the cloud would, by varying its position, be reduced in volume in the same proportion as the air in which it was suspended?

The theory of M. Valz was based upon data furnished by the observations and deductions of Encke, viz., the existence of a fluid in space having inertia. Being possessed of inertia, it would be most unphilosophical to believe it wanting in the other properties of matter, especially those of the aeriform bodies. His explanation was, in my opinion, a masterpiece of reasoning.

The three phenomena of comets I have now spoken of, and which have been by different astronomers ascribed to the influence of ether, are features which are believed to characterize comets as a class; they constitute a rule which applies to all these bodies.

It is true, some of the greatest lights which adorn the science of astronomy, disbelieve in the connection between ether and these phenomena. This slowness to receive new ideas, has characterized eminent men in all ages, and persons of the greatest learning, whose efforts have been most availing, in the advancement of astronomy, have died in utter unbelief in doctrines, in which their contemporaries and immediate successors have placed general and implicit credence.

Tycho Brahe, who, during his whole life, had the benefit of the truths contained in the great work of Copernicus "De Revolutionibus," believed in the immobility of the earth, and in the daily revolution of the sun and planets round the same.

What is more remarkable still, these views were held by the expounder of the inductive philosophy.* If anything could shake our confidence in the value of Bacon's exclusive system, it is the fact, that with the truth before him, his inductive philosophy failed to prevent him from believing in error.

I shall now draw attention to two cometary phenomena which, unlike the three already spoken of, are exceptional. I am not aware that any attempt to explain them has ever been made; but if the ether with its circulation through the solar system exists, as it is the purpose of this paper to describe, the explanation of both will be simple and satisfactory.

* See Bacon's essay "On the Ebb and Flow of the Sea."

The comet which, during the last century and a half, has, more than any other, given rise to the speculation, the calculation, the wonder, and the triumph of astronomers, is unquestionably that of Halley.

The comet in question furnishes us with a single known exception to the law, that as comets approach the sun the splendor of their tails increases, and after passing their perihelia gradually diminishes to their final disappearance.

History records eight different visits of Halley's comet to its perihelion, from the year 1305 to 1835 inclusive.

The inclination of this comet to the ecliptic is less than eighteen degrees, and its perihelion distance about half the radius of the earth's orbit. The comet, while approaching and receding from its perihelion, must, therefore, have passed through that part of the solar system where the ascending current of ether exists in greatest force.

If the ethereal current have any power to detach the tail of a comet from its nucleus, by the force of its blast, we might suppose it should be conspicuously displayed upon Halley's comet.

During five of the visits of Halley's comet to its perihelion, we have the testimony of the contemporary astronomers that the tail diminished or disappeared on approaching the sun, or that it reappeared and expanded after passing the nearest point to that orb. Sir John Herschel, in the year 1835, recorded both of these phenomena.*

* Halley's comet passed its perihelion June 8th, A. D. 1456. I extract from "Pingrê's Cométographie" the following notices of this visit of the comet:

"Although two Polish historians assure us that the size of this comet had not appeared great in Poland, all others agree in representing it as grand, terrible, of an extraordinary size, and carrying in its train a tail which covered two signs, or sixty degrees."

"This tail, however, was not always of the same length: it was observed of thirty spans; it was observed of more than one hundred spans; sometimes no trace of a tail could be seen." (Vol. i, p. 459.)

The 6th June the length of the tail was twenty-two degrees. (p. 461.)

"Another contemporary historian says, the 3d June, the tail was ten degrees, as he satisfied himself with instruments." (p. 461.)

"At Bologna, in Italy, where the latitude is 44° 30′, the comet set, but for a short time, its tail, moreover, after having entirely disappeared, was about to reappear. Ne devait pas tarder à reparaitre." (p. 462.)

In 1531 Halley's comet passed its perihelion August 24th. Pingré says, "The most valuable observations we have of the comet of 1531, are those of Apian, the astronomer of the Emperors Charles V, and Ferdinand I. He began his observations the 13th August. He noticed that in general the tail was opposite the sun, and that it disappeared when the comet approached the horizon, so that he thought at first that a cloud obscured the view." (Vol. i, p. 487.)

Inasmuch as the tails of comets become brighter on approaching the horizon in their diurnal motion, owing to the increasing darkness, I conclude that the astronomer Apian must have referred to the comet's orbital motion, which is equivalent to saying that as the comet approached the sun, its tail disappeared.

I am now about to discuss the last of the cometary phenomena which I think admits of explanation by the influence of ether.

When endeavoring by the aid of *à priori* reasoning to trace out the course of the grand ethereal currents which circulate through the solar system, I pointed out the necessity for the existence of two currents of ether, which should descend upon the sun's polar regions; and hinted that analogy justified the belief that the polar currents descend upon the sun's surface in the form of vortices.

An interesting question naturally associates itself with these views, viz. What effect should be produced upon a comet which passed through the regions where these currents prevail?

We will suppose the comet before entering the region to present the normal features of these bodies. If it be furnished with a tail, we will suppose that it is pointed in the direction away from the sun.

Passing into the vortex, the head of the comet should undoubtedly feel the effect of the downward current before the distant portions of the tail. We might, therefore, expect to see the old tail, while pursuing its trajectory, gradually leave the head, and a new tail, entangled by the descending current of ether, carried in a direction obliquely towards the sun.

In 1607 Halley's comet passed its perihelion October 26th. "The tail was visible from the time the comet was first perceived by Kepler, on the 16th September, until the 12th of the following month." (Hind, Comets, p. 36.)

In 1759 Halley's comet passed its perihelion March 12th. Pingré says, "La Nux did not content himself with observing the nucleus; he was attentive also in measuring the length of the tail. He found it on the 21st April, 8 degrees; the 28th April, 25 degrees; May 1st, 33 to 34 degrees; May 5th, 47 degrees. It lessened afterwards. May 14th, it was only 19 degrees." (Cométographie, vol. ii, p. 65.)

In 1835 Halley's comet passed its perihelion November 15th. Sir John Herschel says: "It was not before the 2d October that the tail began to be developed, and thenceforth increased pretty rapidly, being already 4° or 5° long on the 5th."

"It attained its greatest length (about 20°) on the 15th October. From that time, though not yet arrived at its perihelion, it decreased with such rapidity that already, on the 29th, it was only 3°, and on November 5th, 2½° in length. There is every reason to believe that before the perihelion, the tail had altogether disappeared, as, though it continued to be observed at Pulkowa up to the very day of its perihelion passage, no mention whatever is made of any tail being seen."

"Professor Struve says, the nucleus appeared like a stream of fire which issues from the cannon's mouth after discharge, when the sparks are driven back by a violent wind." (Hind, p. 48.)

"As the comet receded from the sun, the coma speedily disappeared, as if absorbed into the disc, which, on the other hand, increased continually in dimension. . . . While this increase of dimension proceeded, the form of the disc passed, by gradual and successive additions to its length, in the direction opposite to the sun, to that of a paraboloid. . . . It is evident that had this process continued with sufficient light to render the result visible, a tail would have been ultimately reproduced, but the increase of dimension being accompanied with diminution of brightness, a short, imperfect, and, as it were, rudimentary tail only, was formed, visible as such, for a few nights,

After passing through, and out of the downward current, we should expect to see the new tail separate from the head, and another appendage restored in the normal direction.

On examining the catalogue of comets in Mr. Hind's "Descriptive Treatise," I find in the present century only four, the inclination of whose orbits was more than seventy degrees, and whose perihelion distance was less than one-fourth of the radius of the earth's orbit.

Of these four comets, it is recorded of three that they had *double tails.*

The first is that of 1823, the inclination of whose orbit was 76° 11′ 57″, and whose perihelion distance was 0.22650. The following interesting account of its remarkable appearance is furnished by M. Arago.

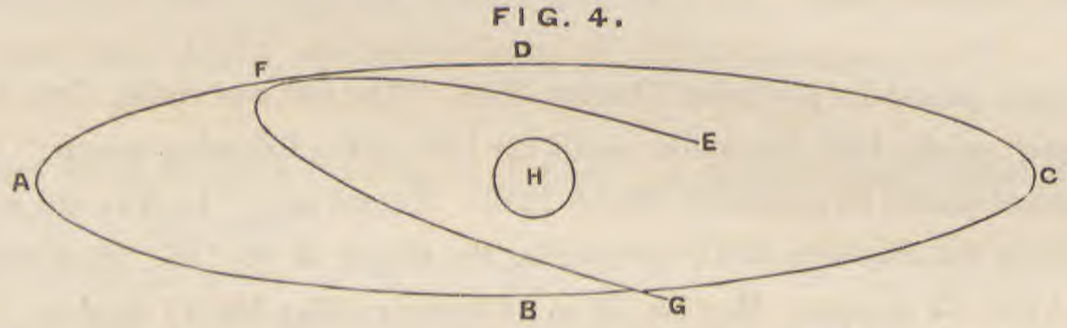
"The comet of 1823 (No. 140 of the catalogue) had two tails, and, strange, while one, as is usual, was pointed away from the sun, the other was turned towards that luminary, which gave it a resemblance to the nebula in Andromeda."

"On the 23d January, 1824, the ordinary tail seemed to be 5° long, the length of the

to the naked eye, or in a low magnifying telescope, and that only when the comet itself had begun to fade away by reason of its increasing distance." (Herschel's Outlines, chapter xi.)

ORBIT OF HALLEY'S COMET.

FIG. 4.

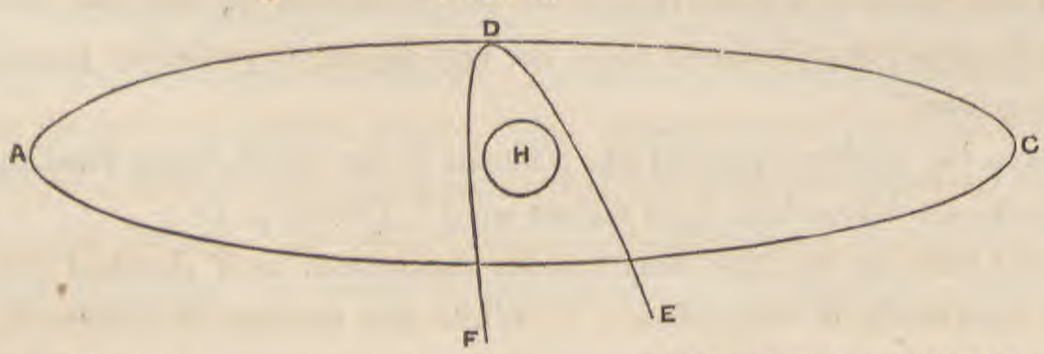


A B C D, The earth's orbit.
E F G, The comet's orbit.
H, The sun.

Inclination, 17° 45′ 5″.
Perihelion distance, 0.58657.
Longitude of perihelion, 304° 31′ 32″.
Longitude of ascending node, 55° 9′ 59″.

ORBIT OF THE COMET OF 1823.

FIG. 5.



A B C D, The earth's orbit.
E D F, The comet's orbit.
H, The sun.

Inclination, 76° 11′ 57″.
Perihelion distance, 0.22650.
Longitude of perihelion, 274° 34′ 30″.
Longitude of ascending node, 303° 3′ 0″.

other was scarcely 4°; their axes formed together a very obtuse angle of 160°. Near the comet the abnormal tail could scarcely be seen; its brightest point was 2° from the nucleus. In the early days of February, the tail opposite the sun could alone be seen; the other had disappeared, or had become so feeble that the best night glasses, in clear weather, gave no trace of it. These results are a summary of observations made at Paris, Marseilles, Marlia, Bremen, Gottingen, and Prague. No comet had up to that time presented so extraordinary an appearance."*

The second comet of this class was that of 1825. The inclination of its orbit was 89° 22′ 10″, and its perihelion distance 0.02689. M. Arago gives the following account of it.

"The tail of the comet of 1825 (No. 145 of the catalogue), observed in New Holland by Mr. Dunlop, consisted of six distinct branches of different lengths. On the 19th October, the rays proceeding from the tails on the extremes, seemed to cross behind the comet like rays which diverge from the focus of a lens. On the 1st November, we find in Mr. Dunlop's account expressions not less explicit. At one degree and a half from the head, rays from the different tails diverge indefinitely, in such a way that the rays forming the right border of the tail come from the left of the head, and reciprocally."†

It would not be easy to describe more precisely the probable effect upon a comet's tail of being caught in a vortex of ether.

The last comet of this class was the fourth comet of 1851, discovered by M. Brorsen. The inclination of its orbit was 73° 59′ 44″. Its perihelion distance was 0.14132.

It is No. 193 of M. Arago's catalogue, who states "that it had two unequal tails, of which the shorter was directed towards the sun."‡

We have it recorded of many comets, as was the case with Halley's in 1835, that a ray of light was ejected from the anterior surface of the nucleus, which finally became involved with the tail; but no other comets seen in the present century have exhibited the appearance of those just described.

ETHER. ITS RELATIONS TO THE SEASONS.

The subject of ether in its bearings upon the zodiacal light and comets, is one which interests alone the man of science; if it can be shown, however, that the amount of heat which our planet receives from the sun, is supplied partly by the agency of ether, and if the periods when these accessions of caloric are likely to occur, can be pointed out, the subject increases in importance, and the agriculturist, the physician, and, indeed, the world at large, will share with the astronomer the interest which the subject inspires.

In my efforts to trace out the course of the grand ethereal circulation, I arrived at the conclusion that the ascending current has nearly the form of a plate whose sides decline a

* Astronomie Populaire, vol. ii, p. 407. † Id., p. 408. ‡ Id., p. 408.

little from the plane of the sun's equator, so as to give it the character of a hollow cone, the sun's centre occupying the apex of the cone.

The fact of the zodiacal light being seen more than ninety degrees from the sun, I respectfully submit, may now be adduced as evidence that the current extends beyond the earth's orbit.

If there be reality in the conditions I have endeavored to portray, it follows that our planet must, twice in every revolution round the sun, pass through the ascending current of ether; and if, at the distance of the earth's orbit from the sun, the current retain a portion of heat above that of the surrounding medium, we should, while passing through the mass, look for an increase of temperature in all parts of the globe, where special causes do not affect the climate too forcibly to permit the influence of the ether to be observed.

In order that the temperature of our planet should be affected by that of the surrounding medium, it is not necessary that the temperature of space should, by any means equal that of the coldest part of the earth; and for the following reasons. All bodies radiate heat to the objects and the space in their vicinity, and the amount of caloric which any body loses by radiation, is dependent in a measure upon the capacity for receiving heat possessed by the bodies in its vicinity. Thus, if while passing through the ascending current of ether, the earth lose a less amount of heat by radiation than in other parts of its orbit, a larger portion will remain to affect our senses.

The exact position and direction of the ascending current becomes a subject of absorbing interest. The only data we possess for determining these points are the causes believed to be concerned in its origin and propagation. We are, therefore, forced to pursue the *à priori* system of reasoning.

As has been already stated, the ascending current of ether takes its origin from a vast zone of the sun's surface, extending many degrees on each side of the equator, the larger portion being to the north of that circle.

If the equator divided this zone into equal parts, and if, indeed, the maximum heat of the sun's surface were on the line of the equator, then a very simple course of reasoning would teach us that our planet must pass through the heated mass at the points of its orbit intersected by the plane of the solar equator. We should, therefore, look for seasons of warmth about the sixth days of June and December.

Inasmuch, however, as the sun's northern hemisphere is hotter than the southern, and as the line of maximum heat lies 1° 29′ 6″ north of the equator, the problem becomes less simple; highly interesting complications are developed, and we find our attention drawn to a subject which, as far as men's published thoughts go, is a new field of research.

Before progressing further in this investigation, it is indispensable to call to mind the precise relations of the sun's equator to the ecliptic. It is inclined, according to M. Arago,

about seven degrees. The declination of the north pole of the sun from that of the ecliptic, is in the direction of longitude 345°. The earth passes through the point of its orbit corresponding in longitude on the 8th September.

If the declination of the ethereal current from the plane of the sun's equator equalled the inclination of the latter to the ecliptic, viz., 7°, the earth would encounter the mass at only one point in its orbit, at D.* (See Plate I, fig. 6.)

The declination being less than 7°, the earth must meet the heated mass at two points, the one between B and D, and the other between D and F.

We have now to consider another element which influences the direction as well as the position of the ascending mass, viz., the motion given to the columns by the sun's axial rotation.

If, after leaving the solar surface, the columns retained a tendency to move in circles round the sun's axis, we should infer that the points where the earth traversed the mass were equidistant from longitude 345°.

But, inasmuch as the columns of ether should, after leaving the sun, be impelled in tangents to the circles they revolved in while upon the sun's surface, a different solution to the problem must be found.

To this point I have given much reflection, and am firmly of the belief that a translatory motion of the ethereal columns in the direction of an increase of longitude, should bring the ethereal mass into contact with the earth's orbit at two points whose mean is more advanced in longitude than 345°.

We have, therefore, to look for two periods of warmth between the months of June and December, produced independently of the sun's declination, or any other cause to which changes of the seasons have been heretofore ascribed.

* The circle H, in the centre of the figure, is the sun, which, for convenience of demonstration, we will suppose surrounded at the distance of the earth's orbit by an imaginary sphere, represented by the outer circle.

A B C D E F G, is the earth's orbit, seen obliquely.

I G B K F, is the solar equator projected upon the imaginary sphere.

L C M E, is a small circle projected upon the imaginary sphere, showing where the ethereal current passes through it.

The curved lines within the circle, are the columns of ether passing through the interplanetary space.

The point A is in longitude 165°, and D in 345°. The latter is the direction towards which the sun's north pole is inclined seven degrees.

The earth is at A, on the 6th March; at B, on the 6th June; at D, on the 8th September; and at F, on the 6th December.

At C, the earth's orbit intersects the ethereal cone, the planet (by theory) passes that point on the 10th August; the epoch of the mean of the canicular days.

At E the orbit again intersects the cone of ether, the planet passes that point theoretically on the 12th November, the epoch of the mean day of the Indian summer.

The mean day of the interval separating these seasons of warmth, must be more advanced in the year than the 8th September.

Have such seasons been observed?

Have names been assigned to them?

Since the earliest days of civilization, it has been known that the greatest heat of summer does not coincide with the summer solstice. The ancient Egyptians, noticing that certain days, remarkable for sultry heat, occurred about the beginning of July, at which time the dog star emerged from the sun's rays, gave the name of the star to the season, which is generally known as the canicular, or dog days. According to the almanacs, they are reckoned about forty, beginning on the 3d July, and ending the 11th August. This was doubtless true in the days of the Pharaohs, but, at the present time, the canicular days are correctly estimated by M. Bescherelle to begin about the 24th July, and end the 26th August.

Mr. Brande says, "Owing to the precession of the equinoxes, the heliacal rising of Sirius now takes place later in the year, and in a cooler season; so that the *dog days* have not now that relation to the particular position of the *dog star*, from which they obtained their name."

In this I must disagree with Mr. Brande. The dog days still bear their old relation to the rising of the dog star.

Astronomers have not yet discovered that the sun's axis undergoes any change in position, though theoretically it must from planetary influence, revolve about the pole of the ecliptic, just as the earth's axis does, but in an inconceivably long period. We may, therefore, consider the sun's axis as firmly fixed as the place of Sirius, and look for a continuance of the occurrence of the dog days with the heliacal rising of Sirius.

Besides the heat and sultriness which characterize the dog days, there is another feature which is a very usual attendant, viz., an obscurity in the atmosphere which does not appear to be associated with moisture, smoke, or dust. It sometimes comes on so rapidly that, in the course of four or five hours, a whole landscape, as far as the eye can see in every direction, is affected by it. I have known this state of things to continue six days at a time, in spite of the intervention of a strong wind and rain.

It may possibly never be determined what the origin of this obscurity is. I will observe, however, that it is a part of this theory of ethereal currents that, during the dog days, our planet is passing through the substance of the zodiacal light.

The only explanation of the cause of the canicular days, I have ever heard of, is that of the Egyptians; viz., the malignant influence of the dog star.

If M. Bescherelle be correct in his estimate of the number, and time of occurrence of the dog days, viz., from the 24th July to the 26th August inclusive, their number is thirty-four, and the morning of the 10th August is the period of their greatest intensity.

After passing through the heated stratum, our planet is, for a few weeks, on the north side of the mass, or inside the ethereal cone. (See Plate I, fig. 6.)

During this time the autumnal equinox occurs. The declining power of the sun, and increasing length of the nights, seem to produce a rapid advance toward winter. But the earth soon approaches and enters the ethereal mass the second time in the year, and the progress of winter seems stayed. Again our atmosphere is obscured, the sun's disc looks red, and the mornings and evenings seem to rival the noontide in warmth. These phenomena appear the more striking, because they often take place after the occurrence of frosts.

This delightful season is known over the North American continent, from New England to California, and from Canada to Mexico. In the United States and Canada it is called the "Indian Summer," and in Mexico, "Veranillo de San Martin,"* the little summer of St. Martin.

The name of Indian summer was probably given to it by the English colonists, because the season being unknown in the British islands, they supposed it to be peculiar to their new home. The Mexican name is the one used in Spain.

It is known in France as "L'été de St. Martin," and in Southern Europe by names of similar import.

In Germany it is called "Alter Weiber Sommer" (old woman's summer). In Russia, "Babie Leto;"† meaning the same as the last. In Sweden, "Efter Sommarn,"‡ the after summer.

At Rio Janeiro, at the time of the year when the Indian summer prevails in the northern hemisphere, the atmosphere has the obscurity which characterizes the season.§

The Indian summer does not make its appearance on a fixed day in the year, its approach (in America) is gradual. Some days possessing its features are generally observed in the end of October; they occur at intervals, and in periods of varying duration through November, and the influence of the season is sometimes felt in the early part of December.

The burning of the grass on the prairies by the Indians in North America, has been given as the cause of the warm weather and obscured atmosphere of this season. The phenomena being observed in Europe, is a sufficient refutation of the hypothesis.

The name given to the season in the south of Europe, and in Mexico, is perhaps the best indication of the period of its greatest intensity.

The feast of St. Martin is celebrated on the 11th November.

Thus, we find that in the time of the occurrence of the canicular days, as well as of the

* Señor Felix Merino, Consul, Philadelphia.

‡ Mr. Carl Arfwedson, Stockholm.

† Comte de Bouxhoevden, Russian Army.

§ Dr. Charles Eversfield, U. S. Navy.

Indian summer, popular observation has supplied us with data which the notes of astronomers have failed to furnish.

There are some parts of the world where the force of special causes is such as to prevent the Indian summer from being felt. In the British islands the climate is, in a great measure, determined by the influence of the Gulf Stream. On the coast of California the Indian summer is not known, probably from the existence of the *Kuro Siwo*,* or *Japan Stream*, a current in the Pacific Ocean, having geographical analogies with the Gulf Stream.

In the polar regions of the earth, the influence of the sun's rays in producing heat, is at its minimum, while any effect derived from the medium by which our planet is surrounded, is, except in special cases, equally displayed in all parts of the earth.

Any depression in temperature, owing to ethereal influence, must be most perceptible in the polar regions, because there the other cause of heat is at its minimum.

In the month of March our planet attains its extreme distance from the ascending current, we should, therefore, look for the greatest degree of cold in the polar regions in that month.

Dr. E. K. Kane, during the winters of 1853–4 and 1854–5, spent in lat. 78° 37′, on board the brig Advance, found the coldest weather in the month of March.†

Dr. I. I. Hayes, who was surgeon to the expedition under Dr. Kane, confirms his report of the temperature of the weather in March.

Dr. Hayes also passed the winter of 1860–61 on board the schooner United States in lat. 78° 17′. The coldest weather of that year occurred in the month of March.‡

According to this observer, such is the uniform experience of Arctic navigators.

Even in the temperate regions of the earth, the month of March is a most boisterous season. One of its peculiar features is a chilling atmosphere, accompanied by considerable power in the sun's rays. It is said to "come in like a lion, and go out like a lamb;" an order of events to which not only the obliquity of the ecliptic, but also the relation of the sun's equator to the earth's orbit, eminently conduces.

At the opposite season of the year, in the month of September, the earth reaches its extreme distance from the ethereal current, for that half of the year.

From the relation of the ethereal current to the solar equator, the earth does not then attain the same distance from the heated mass as in the month of March. We cannot expect, therefore, to find the same degree of cold exhibited in September as in March. And such is common experience.

* See "A paper on the Kuro Siwo, or Japan Stream." Read before the American Geographical and Statistical Society by Silas Bent, Lieutenant U. S. Navy. New York, January 24th, 1856.

† In a private conversation.

‡ In a narrative delivered to the Academy of Natural Sciences, Philadelphia, November 26th, 1861.

Our theory teaches us that ethereal influence causes two maxima of heat in a year, occurring in the months of August and November; also a maximum of cold in the month of March, and a lesser degree of cold in September.

The first three phenomena are of sufficient intensity to be distinctly evident to our senses.

The object of this paper is to point out the periods when accessions of heat and the occurrence of cold from ethereal influence are likely to take place; not to limit the time when they are possible.

As the sun's equator is only inclined by seven degrees to the ecliptic, it is not likely that any part of the earth's orbit is wholly beyond the influence of the ascending mass of ether.

I have certainly observed in the months of February and April, days in which the redness of the sun, the warmth and peculiar opacity of the air, called to mind the features of the Indian summer.

In discussing the question of the possible influence of comets upon our planet, M. Arago mentions the occurrence, on two occasions, of the phenomenon of dry fogs. The first was in the year 1783, began on the 18th June, was observed over the whole globe at the same time, and lasted more than a month.*

The second, occurred in the year 1831. It was observed first on the coast of Africa, August 3d; at Odessa, August 9th; in France, August, 10th; in New York, August 15th; in China, the end of August.

With regard to the fog of 1783, M. Arago mentions two explanations proposed by Franklin. 1st. The dissemination by winds of the smoke of Mount Hecla, which was in eruption during the whole summer. 2d. The imperfect combustion in our atmosphere of an immense meteor.

Any one having faith in the theory I have endeavored to establish, on noticing the time of the year when the dry fog of 1831 occurred, would certainly ascribe it to a cause identical with that which produces the opacity in the air during the continuance of the dog days.

The proposed combustion of the meteor in our atmosphere, seems to me a weak point in Franklin's hypothesis, because, if a combustion had occurred of sufficient magnitude to fill the whole earth with its smoke, it is remarkable that the light and other results of combustion were not observed.

My own belief is, that in both instances the obscurity was caused by an emanation from the sun, transported to the earth by the ascending current of ether, and the phenomena were closely allied in character to the seasons of warmth known as the dog days, and the Indian summer.

* Astronomie Populaire, vol. ii, chap. 36.

ETHER. ITS RELATIONS TO PERIODICAL SHOOTING STARS.

With the seasons of warmth, whose causes I have endeavored to determine, there seems to be allied by a nice coincidence in time, a phenomenon of a very different character. I refer to periodical shooting stars.

The first of these phenomena in the order of the year, appears on or about the 10th August, a time which corresponds exactly with the mean occurrence of the dog days.

The other exhibition is observed on the 12th November, and to show the closeness of the coincidence in time with the Indian summer, we may call to mind that this season in the south of Europe is known as the summer of St. Martin; the festival of which saint is celebrated on the 11th November.

Shooting stars being one of the most beautiful and striking features of night, men have, in all ages, made their origin and nature a subject of speculation.

An intelligent compiler has classified the various explanations offered upon the subject, into the following five hypotheses: the atmospheric; the volcanic; the planetary; the lunar; and the nebular.*

This classification is imperfect, as it does not include Professor Olmstead's scheme of a nebula revolving round the sun once in six months, and meeting the earth on the 12th November;† nor that adopted by Sir John Herschel, in which a broken stream or annulus of meteors is encountered by the earth in a certain part of its orbit: the breaks in the annulus corresponding with the omissions of the exhibition.

I stated my objection to Professor Olmstead's hypothesis when treating of the zodiacal light, in its requiring a precise coincidence in the periodic time of two bodies moving independently of each other.

The explanation of the broken stream of meteors has received the support of many of the most distinguished savants of Europe, among others, of Poisson, Arago, and Von Humboldt. It is bold, and to my view arbitrary, as it has no analogies with known astronomical facts to give it probability; nor is any other phenomenon of nature explained by it. It appears, too, that this hypothesis does not exhibit that ingenuity which we look for in a scheme supported by such distinguished men, for Sir John Herschel says: "We need not suppose the meteoric ring coincident in its plane with the ecliptic."‡ This debars its defenders of the ability to account for more than one exhibition in a year, unless they occurred at precisely opposite seasons.

* Lardner's Lectures on Science and Art, vol. i, p. 461.

† American Journal of Science and Art, vol. xxix, p. 376.

‡ Outlines of Astronomy, chapter xvii.

The explanation is a graft induced by the periodicity of the phenomenon upon the theory of Chladni.* It is a mere addition, however, not an improvement.

The two grandest exhibitions of shooting stars recorded in modern times, occurred on the night of the 12th November, in the years 1799 and 1833. Many observers claim to have seen wonderful displays of the phenomenon on other anniversaries of the 12th November. The belief is strong, however, among astronomers, that the displays of 1799 and 1833, were incomparably superior to those of any other years.

Olbers, the celebrated physician and astronomer of Bremen, suspected that these grand exhibitions would only occur at intervals of thirty-four years.†

Von Humboldt says, "The acute mind of Olbers led him almost to predict that the next appearance of the phenomenon of shooting stars and fire-balls intermixed, falling like flakes of snow, would not recur until between the 12th and 14th November, 1867.‡

It would have been prudent in the philosopher of Bremen to have given the world the data upon which his prediction was founded. If his only ground for making it were, that the time which had elapsed between 1799 and 1833, when added to the latter date, will bring us to 1867, we can award him but a slender meed of praise. A man of less ability might have made a surmise as likely to prove correct.

The explanation which I am about to offer for the phenomenon of periodical shooting stars, is a part of the grand scheme of ethereal currents. Up to this time, I have asked for the admission of no new astronomical condition, without accompanying it with independent evidence of its existence. This constitutes the scheme a theory. I shall now be obliged to bring forward one or two points which are hypothetical, but I trust the remarkable numerical coincidence which I shall adduce in support of these points will lead to their adoption.

Experiments made with the spectroscope by Messrs. Bunsen and Kirchoff, upon the flames of various combustible metals, and a comparison of the resulting phenomena with the dark lines of the solar spectrum, have led them to the conclusion, that the sun consists of an ignited solid or liquid central body, throwing off white light, and an atmosphere containing iron, sodium, lithium, and other metals in a vaporous state, yet capable of absorbing parts of the white light.§

Upon these positive results, I now postulate that a portion of the metals in the solar atmosphere escape from the sun without undergoing the chemical change which produces the light and heat; that the portions of the sun's surface from which these metals escape are limited in number and small in extent; that the vaporous metals are, by the ascend-

* Milner, Gallery of Nature, p. 137. † Astronomie Populaire, vol. iv, p. 329. ‡ Cosmos, vol. i, p. 127.

§ London, Edinburgh, and Dublin Philosophical Magazine, or Journal of Chemical Society, London, 1861 and 1862.

ing current of ether, carried to the region of the planets; that the stream of metallic vapor* reaching the earth's orbit, at the time and place where the planet is passing, will be ignited by its atmosphere, and produce the phenomenon of a shower of shooting stars; and lastly, that the stream which produced the meteors of November 12th, in the years 1799 and 1833, issued from one and the same spot upon the sun's surface.

An encounter between the metallic stream and the earth, can only occur at two points in its orbit, viz., where it passes through the centre of the ethereal current. Our experience with the seasons has determined these epochs to be the 10th August, and about the 11th November. The incident can only take place at those times, when the portion of the sun's surface which emits the metallic stream is favorably situated to produce an encounter with the earth.

A candid listener, on hearing this proposition, would, in view of the overwhelming odds against finding a coincidence, be apt to exclaim, "We will grant your postulates, if you can show the existence of a *cycle of solar rotation* coinciding with thirty-four orbital revolutions of the earth."

Unpromising as the chance of finding the required coincidence may appear, it nevertheless exists; and is, moreover, one of remarkable exactness.

If we take the number of days in the sidereal year, and multiply it by the interval between the two great exhibitions of shooting stars, and divide the product by the period of the sun's rotation, thus,† $365.256 \times 34 = 12418.704 \div 25.5 = 487.008$, we shall get as a quotient the number 487.

The coincidence may be made more striking by another mode of exhibition:

$$365.256 \times 34 = 12418.704.$$
$$25.5 \times 487 = 12418.5.$$

Thus, we find there is a cycle of solar rotation, in which 487 rotations of the sun correspond in period with 34 revolutions of the earth in its orbit; thus, too, it is proved by the simplest rules of arithmetic, that any part of the sun's surface, turned towards the earth at any given point in its orbit in the year 1799, was also turned towards the earth at the same point in its orbit in the year 1833, and will be again in the years 1867 and 1901.

The difference between the two periods is only two-tenths of a day, or four hours and forty-eight minutes.

* I have used the expression, metallic vapor, for want of a better, to describe the condition of the metals when in the sun's atmosphere, and while being transported by the ethereal current to the earth's orbit.

A metallic vapor, doubtless, it is while in the sun's atmosphere, but the many recorded occurrences of the fall of *meteoric dust*, may give us a clue to the true condition of the metals while making the journey through the planetary spaces.

† Astronomie Populaire, vol. ii, p. 86.

The knowledge of this coincidence lends an interest to the quasi prediction of the intelligent Olbers, which before it wanted; and its fulfilment, should it occur, will certainly give stability to the theory which induced the search for and discovery of the cycle of solar rotation.

Theophanes, one of the Byzantine historians, records that, in November of the year 472, the sky appeared to be on fire over the city of Constantinople, with coruscations of flying meteors.*

Deducting the year 472 from 1799, gives us 1327, which is one year more than 39 cycles of solar rotation. The fact is, therefore, only interesting to us, as it awakens the suspicion that the historian who recorded an event occurring three centuries before his own time, may have erred in the date by a single year.

The considerations which induced me, when investigating the influence of ether upon the seasons, to conclude that the mean day between the dog days and the Indian summer, should be more advanced in the year than the 8th September, have a similar bearing upon the subject of periodical shooting stars.

Between the 10th August and the 12th November, the mean day is the 26th September, which is eighteen days after the 8th September. It is a fair subject of inquiry, What is the significancy of these eighteen days?

Without being able to offer an opinion for which I can furnish a basis, I respectfully submit that, under the influence of the tangential force, acting upon the metallic stream after leaving the sun, the eighteen days represent the time required for the vaporous metals to reach the earth's orbit.

The investigation of the relations between the period of the sun's rotation and the sidereal year, not only teaches us that there is a very great probability of a display of shooting stars on the 12th November, 1867, but further, that there is a lesser probability of a smaller exhibition on the anniversaries of that day in the years 1864 and 1870, and for the following reasons:

The number of days in three years is 1095.795. This is just sixteen hours and fifty-five minutes less than forty-three rotations of the sun.

In a whole cycle of solar rotation, the years which show the greatest probability of a meteoric display, after the termini of the cycle, are the third year before, and the third year after those epochs.

It is not likely that the inhabitants of the countries which witness the displays at the termini of the cycles, will also see those which may occur at the triennial anniversaries; as the longitudes of the places where the three phenomena will be visible are different.

On examining Figure 6, showing the relation between the earth's orbit and the ascend-

* Gallery of Nature, p. 138.

ing current of ether (which, hypothetically, is the great reservoir of meteoric matter), we may draw conclusions regarding the probable frequency of shooting stars in different seasons of the year.

The earth is at A on the 6th March, at B on the 6th June, at C on the 10th August, at D on the 8th September, at E on the 12th November, and at F on the 6th December.

It is evident that while passing from F to B, the planet is more distant from the ethereal current than while performing the other half of its yearly course. Consequently, we should then expect to observe a comparatively small number of shooting stars.

While passing from B to F, the planet is twice carried through the ethereal current, and is at no time far removed from it. The distance is greatest in September.

The richest displays of shooting stars might, therefore, be reasonably expected during the last half of the year.

M. Arago furnishes several very interesting tables connected with observations upon sporadic shooting stars. I have copied below that of MM. Coulvier Gravier and Saigey, which is the mean monthly number of shooting stars seen during the hour which includes midnight.

January,	3.6	July,	7
February,	3.6	August,	8.5
March,	2.7	September,	6.8
April,	3.7	October,	9.1
May,	3.8	November,	9.5
June,	3.2	December,	7.2*

By comparing this table with Figure 6, its agreement with the conclusions drawn from the *à priori* argument is striking.

The circulation in the ether is a process which I have taken the pains to deduce from conditions ascertained by different astronomers for abstract purposes. I have pointed out its influence in the production of the zodiacal light, and shown some new effects upon the tails of comets, and its influence upon the seasons. Taken in connection with the rotation of the sun, and the revolution of the earth in its orbit, I have offered reasons for believing that the ethereal circulation causes the periodicity in shooting stars.

Viewing this process as the result of conditions previously determined, and as the cause of the phenomena I have discussed, its existence may be said to be proved by two systems of reasoning.

I now resign the subject, with the conviction that as it is one of immense interest, and has received no justice at my hands, it will speedily provoke the inquiry of persons who have made special studies of the phenomena which I have endeavored to combine under one cause.

* Astronomie Populaire, vol. iv, p. 289.

ARTICLE V.

ON NEW MOSSES.

BY THOMAS P. JAMES.

Read December 16, 1864.

THE writer submits a catalogue of all the new mosses which he has detected within the limits of the United States east of the Mississippi River, and which were not published at the time of discovery. It includes a revision of those which were reported in his article entitled "An Enumeration of Mosses detected in the Northern United States which are not comprised in the Manual of Asa Gray, M.D.," published in the Proceedings of the Academy of Natural Sciences, December, 1855; also, several species found in localities not heretofore announced. The object in adding the new localities is to exhibit a wider range for future reference in forming a correct list of the geographical distribution of plants.

Botanists have in this country mostly confined their explorations to phænogamous plants, and but little attention has been devoted to the study of anophytes. This study has more recently received an impetus by the well-digested arrangement of the orders Musci and Hepaticæ in the first edition of Gray's Manual. This contribution was the labor of that accomplished bryologist, William S. Sullivant, Esq., and is now the acknowledged authority. In the issue of the second edition these orders received extensive additions and emendations by the same contributor, embracing all the discoveries up to that period, presenting a *vade-mecum* for all students.

The success of the writer in collecting the number reported of plants new to this country, compared to the limited extent of his explorations, should stimulate others to greater exertions in developing the many hidden objects now unknown to science. He has explored some, only, of the rich localities among the Alpine regions known as the White Mountains of New England, and less extensively those of the Alleghany Mountains of Pennsylvania and Catskill Mountains of New York. He has traversed, partially, sections of the midland of Pennsylvania, Delaware, and New Jersey, and in all of them has he been amply rewarded, and in no case have the localities been exhausted.

It is evident that the United States have by no means been thoroughly explored, and that much remains to be accomplished. The Bryological Flora lies open to the young enthusiastic botanist who desires to prosecute so interesting a study.

The author, with lively satisfaction, acknowledges his indebtedness to the eminent bryologist, Leo Lesquereux, Esq., of Columbus, Ohio, for having authenticated most of the plants reported in this catalogue.

SPHAGNUM, *Dill.*

S. COMPACTUM, *Brid.* Var. rigidum, *Müll.* Var. humile, *Schimp.*

Hab. Quakerbridge and other localities in New Jersey. These varieties have hitherto been reported as occurring solely in the Southern States.

S. CYCLOPHYLLUM, *Sulliv. and Lesqx.*

Hab. Batsto, near Quakerbridge, New Jersey.

S. SEDOIDES, *Brid.*

Hab. Ethan's Pond, Willey Mountain, New Hampshire, and Quakerbridge, New Jersey.

S. PYLÆSII, *Brid.*

Hab. Same localities as the preceding. All heretofore considered of Southern origin.

S. FIMBRIATUM, *Wils.*

Hab. Pinkham Notch, near the Glen House, White Mountains, New Hampshire.

Our plant has the stem-leaves less fimbriated than the figured species of Schimper, but corresponding in every other character. Drummond collected this species in British America.

S. CUSPIDATUM. Var. fluitans, *Schimp.*

Hab. Batsto, New Jersey.

PHASCUM, *Linn.*

EPHEMERUM, *Hampe.*

E. SYNOICUM. Sp. nov. Caule cæspitoso, brevi, tenero, basi radiculis in plantis junioribus byssoideis instructo. Foliis inferioribus brevibus, ovato-lanceolatis, superioribus longioribus, lanceolatis vel lineari-lanceolatis, margine integris vel apice areolis exeuntibus subdentatis, enervis, laxe areolatis; perichætialibus conformibus vix longioribus. Inflorescentia hermaphrodita; archegoniis antheridiisque e paraphysatis in eodem perichætio plurimis. Capsulis globosis, vel singulis, vel binis quandoque ternis in eodem perichætio, subsessilibus vel brevissime pedicellatis, Calyptra basi vix dilatata agglutinata longe rostellata. Sporis magnis papillosis.

By the leaves, the general outline of the plant, the areolation, the form of the capsule, and the spores, this species is a true Ephemerum. It differs, however, from all the species of this genus by the hermaphrodite inflorescence. It has obscurely pro-embryonal filaments, although the filaments attached to the roots are, when young, truly byssoid. This species is very remarkable for the number of its capsules, generally two, sometimes three, in the same perichætium. It does not compare with any described species. By

the leaves it approaches Ephemerum tenerum, Hampe, but even these are longer and narrower. The stem, though generally short, is sometimes a little elongated; the leaves are mostly entire, and perfectly nerveless; inferior ones small, and distantly imbricated. Matures in September.

Hab. On damp, clay soil; luxuriates on the surface of clay clods, recently thrown up in constructing ditches. Camden, New Jersey.

PHASCUM TRIQUETRUM, *Spruce.*

Hab. Dry soil, near Woodbury, New Jersey.

P. MUTICUM, *Schreb.*

Hab. On the ground in uncultivated fields, Chester County, in 1850, and Indiana County, Pennsylvania.

P. SCHIMPERIANUM, *Sulliv.*

Hab. Upper Illinois, on the bare ground, heretofore reported exclusively as Texan. *E. Hall.**

P. SUBULATUM, *Schreb.*

Hab. Uncultivated fields in Pennsylvania, New Jersey, and Massachusetts.

This species assumes various phases, some specimens having an unusually broad costa, others short, inferior leaves.

P. PALUSTRE, *Br. and Sch.*

Hab. On sandy soil, New Jersey and Pennsylvania.

BRUCHIA, *Schwæg.*

B. FLEXUOSA, *Schwæg.* Var. nigrescens, *Sulliv.*

Hab. On the ground in uncultivated fields, Cambridge, Massachusetts; heretofore solely from the Southern States.

HYMENOSTOMUM, *R. Brown.*

H. MICROSTOMUM, *R. Br.*

Hab. On the ground in uncultivated fields, Cambridge, Massachusetts.

BLINDIA, *Br. and Sch.*

B. ACUTA, *Br. and Sch.*

Hab. Glen Ellis, Gorham, New Hampshire.

Our plant has leaves not quite entire, but slightly dentate, corresponding in other respects with description.

* Occasionally are inserted species which were not collected by the writer, but which came under his observation, being sent for investigation.

ARCTOA, *Br. and Sch.*

A. FULVELLA, *Br. and Sch.*
Hab. Moist situations on Mount Washington, New Hampshire.

The capsules of this species become more or less plaited or ribbed in age, yet simply a variety.

TREMATODON, *Rich.*

T. AMBIGUUS, *Nees and Hsch.*
Hab. Damp, clay soil, New England and Pennsylvania.

The species T. longicollis, *Michx.*, is found in the Southern States, but T. ambiguus is believed to be exclusively Northern.

DICRANUM, *Hedw.*

D. VIRENS, *Hedw.* Var. Wahlenbergii, *Br. and Sch.*
Hab. Near Ellis River, Pinkham Notch, New Hampshire, and Alleghany Mountains, Pennsylvania.

D. SCHREBERI, *Hedw.*
Hab. On the surface of a broad stone in a swamp near Lancaster, Pennsylvania; rare.

D. PELLUCIDUM, *Hedw.* var.?
Hab. Brattleboro, Vermont, *C. C. Frost.*

D. CERVICULATUM, *Hedw.*
Hab. Roadsides, at Pinkham Notch, New Hampshire, growing intermingled with D. subulatum, *Hedw.*

D. SUBULATUM, *Hedw.* var.
Hab. Same locality.

A variety, with longer capsules and open leaves, found growing with the normal form.

D. MONTANUM, *Hedw.*
Hab. "Glen," White Mountains, New Hampshire, and Andover, Massachusetts.

D. LONGIFOLIUM, *Hedw.*
Hab. On rocks, not uncommon, at the White Mountains, New Hampshire.

D. FUSCESCENS, *Smith.* Var. robustum.
Hab. Mount Washington, New Hampshire.

D. SPURIUM, *Hedw.*
Hab. Catskill Mountains, New York, and White Mountains, New Hampshire, and Batsto, New Jersey.

Var. CONDENSATUM, *Hedw.*
Hab. Santee Canal, S. C., *Ravenel*, and North Carolina, *Dr. Curtis.*

Var. ALBIDUM, *Schimp.*
Hab. On sandy soil, Florida, *Daniel B. Smith.*

OCTOBLEPHARUM, *Hedw.*

O. ALBIDUM, *Hedw.*

Hab. On logs, &c., in swamps, near Enterprise, Florida. *D. B. Smith.*

FISSIDENS, *Hedw.*

F. INCURVUS, *Br. and Sch.*

Hab. Attached to rocks and stones in running streams about Philadelphia, Pennsylvania.

F. TAXIFOLIUS, *Hedw.*

Hab. Along the banks of the Brandywine Creek, Delaware, in 1850, and not uncommon near the Schuylkill River, Philadelphia.

Of this genus the writer has detected other species about Philadelphia, which are new, and, when proper specimens are procured, will be described.

TRICHOSTOMUM, *Br. and Sch.*

T. TORTILE. Var. PUSILLUM, *Br. and Sch.*

Hab. Gravelly soil, roadsides, Philadelphia, Pennsylvania.

This species has not the perichætial leaves embracing at the base, the annulus is simple, the membrane of the peristome is emerged, and the leaves are denticulate at the apex.

BARBULA, *Hedw.*

B. RIGIDA, *Schultz.*

Hab. Near Athens, Illinois, *E. Hall.*

B. TORTUOSA, *Web. and Mohr.*

Hab. Goat Island, Falls of Niagara, and Alleghany Mountains, Pennsylvania.

B. PAPILLOSA, *Wils.*

Hab. On the trunks of buttonwood trees, New Jersey and Delaware, and elm trees, Massachusetts.

B. FALLAX, *Hedw.* Var. brevifolia, *Müll.*

Hab. Brattleboro, Vermont, *C. C. Frost.*

DIDYMODON, *Br. and Sch.*

D. RUBELLUS, *Br. and Sch.*

Hab. Trenton Falls, New York, 1850.

D. CYLINDRICUS, *Hook. and Tayl.*

Hab. Coventry, Chester County, Pennsylvania, December, 1850, and Alleghany Mountains, Pennsylvania, and Catskill Mountains, New York.

POTTIA, *Ehrh.*

P. SUBSESSILIS, *Br. and Sch.*

Hab. Bluffs, Sangamon River, Illinois, *E. Hall*, and Texas, *Dr. Bigelow.*

TETRODONTIUM, *Schwœg.*

T. REPANDUM, *Funk.*

Hab. On damp ground, near the "Glen House," Gorham, White Mountains, New Hampshire. *Very rare.*

ENCALYPTA, *Schreb.*

E. STREPTOCARPA, *Hedw.*

Hab. Alleghany Mountains, Lancaster County, Pennsylvania, and Falls of Niagara; sterile.

ZYGODON, *Hook. and Tayl.*

Z. LAPPONICUS, *Br. and Sch.*

Hab. Crevices of rocks, Crawford Notch, New Hampshire; near the Wissahickon Creek, Philadelphia, also Mercersburg, Pennsylvania, *Porter.*

Z. MOUGEOTII, *Br. and Sch.*

Hab. Catskill Mountains, New York; Crawford Notch, New Hampshire; and near the Wissahickon Creek, Philadelphia, Pennsylvania.

ORTHOTRICHUM, *Hedw.*

O. OBTUSIFOLIUM. Var. Lesqx., O. Rogeri, Müll., nec Schp.

Hab. On trunks of Lombardy poplar trees, Cambridge, Massachusetts; in similar situations near Philadelphia, Pennsylvania.

O. PUMILUM, *Br. and Sch.*

Hab. On trees, near Philadelphia, Pennsylvania; Camden, New Jersey; and Cambridge, Massachusetts.

O. PSILOCARPUM, sp. nov. (Mss., 1858), Monoicum, dense pulvinatum, pusillum, parce dichotomum, amœne viride, Foliis erecto-appressis, madefactis apertis, ovato-lanceolatis, concavis vix carinatis, margine medio revolutis, apice obtusis vel obtuso-acutis, nervo valido sub apice evanido instructis, areolatione cellulis ovatis chlorophyllosis distinctis utrinque inflatis, vix vel minutissime papillosis, basim versus subquadratis, perichætialibus conformibus sed longioribus; theca immersa, ovata, ore angusto, lævi (leptoderma leiodermaque) vacua amœne pallida, collo elongato, in vaginula incunte. Peristomii duplicis dentibus externis, brevibus, erectis, sordide albidis, granulosis, margine irregularibus, lanceolatis obtusis vel apice erosis obscure articulatis. Ciliis internis 8 fugacissimis vix dentium longitudine æqualibus; versus basin e duplo cellarum serie compositis, irregulariter plicatis. Operculo conico obtuso mamillato. Calyptra sordide albida nuda.

This species differs from O. Canadense, *Br. and Sch.*, by the smooth capsule. Although at times it appears striate when empty, the capsular cells are nevertheless equal, and not at all different at the apparent striæ, which are produced solely by desiccation; by the internal peristome, much more fugacious,—so much so that it is extremely difficult to find the cilioli; also, by the softer leaves. The peristome of this species resembles much that of the O. strangulatum, and yet the latter has the cilioli larger and stronger, and far less fugacious than our species.

Hab. On trees not uncommon about Philadelphia, Pennsylvania, and New Jersey.

O. LEIOCARPUM, *Br. and Sch.*

Hab. On trees, Cambridge, Massachusetts, in 1853.

O. LUDWIGII, *Schwæg.*; O. CRISPUM, *Hedw.*; and O. CRISPULUM, *Hnsch.*

Hab. On trees, Catskill Mountains; White Mountains, New Hampshire, common.

SCHISTIDIUM, *Br. and Sch.*

S. APOCARPUM, *Br. and Sch.*

Var. GRACILE, *Br. and Sch.*

Var. RIVULARE, *Br. and Sch.*

Subvar. ALPICOLUM, *Br. and Sch.*

Hab. These varieties were all collected in the ravines of the White Mountains, New Hampshire.

S. CONFERTUM, *Br. and Sch.*

Hab. Not uncommon about Philadelphia, Pennsylvania.

GRIMMIA, *Ehrh.*

G. LEUCOPHŒA, *Grev.*

Hab. Rocks, Andover, Massachusetts; Catskill Mountains, New York.

G. OLNEYI, *Sulliv.*

Hab. On rocks on the banks of the Wissahickon Creek, Philadelphia, and French Creek, Chester County, Pa.

G. DONNIANA, *Smith.* Var. obtusa.

Hab. On rocks, Mount Washington, New Hampshire.

RACOMITRIUM, *Br. and Sch.*

R. ACICULARE, *Brid.*

R. SUDETICUM, *Br. and Sch.*

R. FASCICULARE, *Brid.*

R. MICROCARPON, *Brid.*

Hab. White Mountain notches, New Hampshire; and Catskills, New York.

ATRICHUM, *Beauv.*

A. CRISPUM, *T. P. James.*

Hab. On the banks of brooks, among tufts of grass, in New Jersey.

POGONATUM, *Beauv.*

P. BRACHYPHYLLUM, *Michx.*

Hab. On clay soil in New Jersey. First in 1851. A species considered peculiar only to the Southern States.

POLYTRICHUM, *Brid.*

P. COMMUNE. Var. PERIGONIALE, *Br. and Sch.*

Hab. Portland, Maine, 1851.

P. STRICTUM, *Michx.*
Hab. Mount Washington, New Hampshire.

BRYUM, *Br. and Sch.*

B. CRUDUM, *Schreb.*
Hab. Gorham, 1851, and other stations at the White Mountains, New Hampshire.

B. LESCURIANUM, *Sulliv.*
Hab. Pinkham Notch, White Mountains, and near the Wissahickon Creek, Philadelphia, Pennsylvania.

B. ELONGATUM, *Dicks.*
Hab. Common at the White Mountains, New Hampshire.

B. NUTANS, *Schreb.* Var. bicolor, *Br. and Sch.*
Hab. Pinkham Notch, White Mountains, New Hampshire.

B. PSEUDO-TRIQUETRUM, *Schwœg.*
Hab. Wet rocks, West Point, New York, and near Rockport, Massachusetts.

B. INTERMEDIUM, *Brid.*
Hab. Falls of Niagara, White Mountains, New Hampshire; and Alleghany Mountains and York County, Pa.

B. CIRRHATUM, *Hppe and Hsch.*
Hab. Lancaster County, Pennsylvania.

B. OBCONICUM, *Hsch.* Var. having leaves with shorter points, and nerve disappearing under the point.
Hab. Florida, *D. B. Smith.*

B. CORONATUM, *Schimp.* Var. with large yellow capsules.
Hab. Florida, *D. B. Smith.*

MNIUM, *Dill.*

M. HORNUM, *Hedw.*
Hab. Common in Pennsylvania and New Jersey.

M. LYCOPODIOIDES, *Brid.*
Hab. Gorham, White Mountains, New Hampshire.

M. CINCLIDIOIDES, *Hueb.*
Hab. Crawford Notch, White Mountains, New Hampshire.

M. HYMENOPHYLLOIDES? *Hueb.*
Hab. Trenton Falls, New York.

M. SPINULOSUM. *Br. and Sch.*
Hab. Common at the Catskill Mountains, New York, and White Mountains, New Hampshire.

RHIZOGONIUM, *Brid.*

R. SPINIFORME, *Bruch.*
Hab. On the ground at the roots of trees, Florida, *D. B. Smith.*

TETRAPLODON, *Br. and Sch.*

T. MNIOIDES, *Br. and Sch.*

Hab. Mount Franklin, White Mountains, New Hampshire.

FONTINALIS, *Dill.*

F. ANTIPYRETICA, Var. GIGANTEA, *Sulliv.*

Hab. In the head waters of the Saco River, Crawford Notch, New Hampshire, where it was collected for the first time in fruit. Not uncommon in Pennsylvania and New Jersey.

F. DISTICHA, *Hook. and Wils.*

Hab. Near Wilmington, Delaware, 1851; and in the head waters of the Saco River, White Mountains.

F. LESCURII, *Sulliv.* Var. GRACILLESCENS.

Hab. Head waters of the Saco River.

F. DALECARLICA, *Br. and Sch.*

Hab. Common in the mountain streams of the White Mountains, in a fine fruiting condition.

F. NOVÆ ANGLIÆ, *Sulliv.*

Hab. In a small stream near Cape Ann, Rockport, Massachusetts, whence the fine fruiting specimens came by which the author determined the species.

DICHELYMA, *Myrin.*

D. FALCATUM, *Myrin.*

Hab. Near the head waters of the Saco River.

D. CAPILLACEUM. Var. SUBULIFOLIUM, *Schimp.*

Hab. Near Cambridge, Massachusetts.

CRYPHEA, *Mohr.*

C. GLOMERATA, *W. P. Sch.*

Hab. On trees, Batsto, New Jersey. A reported Southern species.

LESKEA, *Hedw.*

L. NERVOSA, *Myrin.*

Hab. Crawford Notch, White Mountains, New Hampshire.

PYLAISÆA, *Bryol. Europ.*

P. VELUTINA, *W. P. Sch.*

Hab. Franconia and Pinkham Notches, White Mountains, New Hampshire.

P. POLYANTHA, *Br. and Sch.*

Hab. White Mountains, New Hampshire.

P. JAMESII, *Sulliv. and Lesqx., MS.*

Hab. On the ground under the shade of trees, Chelsea beach, near Boston, Massachusetts.

PTERIGYNANDRUM, *Hedw.*

P. FILIFORME, *Hedw.*

Hab. On trunks of trees, Crawford Notch, New Hampshire.

NECKERA, *Hedw.*

N. OLIGOCARPA? *Br. and Sch.*

Hab. Under surfaces of horizontal rocks and in shaded situations, White Mountains, New Hampshire.

Our plant has a different aspect from European species. It has shorter capsules, inflated under the operculum, and somewhat top-shaped. Better specimens will probably prove it a new species.

N. UNDULATA, *Hedw.*

Hab. Florida, *D. B. Smith.*

HOMALIA, *Bryol. Europ.*

H. JAMESIANA, *W. P. Sch.*

Hab. Catskill Mountains and the White Mountains of New England. Not uncommon.

Mr. W. P. Schimper remarks, after his diagnosis of O. trichomanoides, in a note: "*Obs.* Speciem proximam paulo minorem, foliis longioribus, solidioribus, subfalcato-ligulatis, sicitate longitudinaliter striolatis, operculi rostro et peristomio brevioribus, clar. T. P. James; in montibus Albis Amer. Sept. legit et misit; nomen H. Jamesii in honorem detectoris ei imposui."

HYPNUM, *Linn.*

H. ABIETINUM, *Linn.*

Hab. Catskill Mountains, New York.

H. BLANDOWII, *Web. and Mohr.*

Hab. Wisconsin, *I. A. Lapham.*

H. PALUDOSUM, *Sulliv.*

Hab. Marshes, New Jersey, and near Philadelphia, Pennsylvania.

H. SQUARROSUM, *Linn.*

Hab. Mount Willard, Crawford Notch, White Mountains, New Hampshire.

H. PILIFERUM, *Schreb.*

Hab. Near the Wissahickon, 1852.

H. DEPRESSUM, *Bruch.*

Hab. On moist ground, near the Schuylkill, Philadelphia, Pennsylvania.

This species was detected in 1853, and reported in the "Enumeration" in Proceed. Acad. Nat. Sci., and, from further investigation, its verity is reaffirmed.

H. MOLLE, *Dick.*
Hab. White Mountains, New Hampshire.

H. OCHRACEUM, *Turner.*
Hab. Catskill Mountains, New York, 1850, and White Mountains, New Hampshire.

H. MONTANUM, *Wils., MS., James' Enum.*
Hab. On rocks in mountain rivulets, White Mountains, New Hampshire.

H. GIGANTEUM, *Schimper.*
Hab. In a swamp near Lancaster, Pennsylvania.

H. ADUNCUM. Var. GIGANTEUM, *Br. and Sch.*
Hab. "Ethan's Pond," Willey Mountain, New Hampshire.

H. FERTILE, *Sendtner.*
Hab. Alleghany, Catskill and White Mountains.

H. HAMULOSUM, *Br. and Sch.*
Hab. Crawford Notch, White Mountains, New Hampshire.

Our plant has a shorter capsule and longer operculum than the European species, probably only a variety.

H. PRATENSE, *Koch.*
Hab. On moist ground, New Jersey.
Var. ———.
Hab. White Mountains, New Hampshire.

This plant has leaves more crowded on the stem; more uncinate; and with longer entire points; the perichætial leaves much longer pointed, the point entire, filiform, flexuose, or reflexed. *An. species.*

H. SALEBROSUM, *Hoff.* Var. *Schimp.*
Hab. Byberry, Philadelphia, Pennsylvania.
This is a very fine variety. Differs *operculo longiori.*

H. TRACHYPODIUM, *Br. and Sch.*
Hab. On rocks near Charles River, Cambridge, Massachusetts.

H. CAMPESTRE, *Br. and Sch.*
Hab. On damp rocks, Bucks County, Pennsylvania.

H. REFLEXUM, *Starke.*
Hab. On rocks and at base of trees, White Mountains, New Hampshire.

H. NOVÆ ANGLIÆ, *Sulliv. and Lesqx.*
Hab. Common in Pennsylvania, Delaware, and New England.

H. SOMMERFELTII, *Myrin.*
Hab. Mostly White and Alleghany Mountains.

H. DIMORPHUM, *Brid.*
Hab. Shaded situations, Glen Ellis, White Mountains, New Hampshire.

H. CONFERVOIDES, *Schwæg.*
Hab. Near Lebanon Springs, New York, and Lancaster County, Pennsylvania.

H. SPRUCEI, *Bruch.*
Hab. Goat Island, Falls Niagara, New York.

H. AMERICANUM, *Schp.?*
Hab. Cambridge, Massachusetts.

A species having the areolation of H. curvipes, *Br. and Sch.*, but with longer seta and longer operculum. Doubtfully H. Americanum.

H. IRRIGUUM? *Br. and Sch.*
Hab. Trenton Falls, New York, and Cambridge, Massachusetts. And Var. merging into H. fluviatile, from Sulphur Springs, Virginia.

H. RIPARIUM, *Hedw.* Var. Of a remarkably slender form.
Hab. In a spring, Bartram's, Philadelphia, Pennsylvania.

H. LESCURII, *Sulliv.*
Hab. Lancaster and Philadelphia Counties, Pennsylvania.

H. MUHLENBECKII, *Br. and Sch.*
Hab. Common near Philadelphia, Pennsylvania, and the White Mountains, New Hampshire.

H. DENTICULATUM, *Linn.*
Hab. Similar localities.

H. PULCHELLUM, *Hedw.*
Hab. "Glen," White Mountains, New Hampshire.

H. FULVUM, *Hook. and Wils.*
Hab. Batsto, New Jersey. Considered a Southern species.

H. ELEGANS, *Hook.*
Hab. Near "Glen House," White Mountains, New Hampshire.

H. ROESEANUM, *Hmpe.*
Hab. Gorham, New Hampshire, and about Philadelphia, Pennsylvania.

This species resembles H. Sullivantiæ, *Schp.* It differs in being of smaller size, and leaves with a narrower areolation.

ARTICLE VI.

ON THE NUMERICAL RELATIONS OF GRAVITY AND MAGNETISM.

BY PLINY EARLE CHASE, M.A., S.P.A.S.

[Magellanic Premium Awarded, December 16, 1864.]

THE dependence of magnetism upon currents of some kind, has long been generally admitted; but it has usually been assumed that these currents are of a peculiar nature, and that they require for their development the existence of a magnetic fluid or æther, distinct in its properties from any other form of matter.

A current presupposes an impelling force, competent to produce a tendency of particles toward some particular point, and an inert or resisting medium upon or against which the force is exerted. Motion, whenever it occurs, is always in the direction of least resistance,—a direction that can be calculated by mechanical laws, when all the determining data are known.

That all forces are in some manner mutually connected, so that gravity and magnetism may be more or less convertible into each other, like light, heat, and electricity, was early suspected by Professor Faraday;* but, on account of the impossibility of escaping from the influence of terrestrial magnetism, all attempts to demonstrate their convertibility have been hitherto unavailing. I have elsewhere suggested, as a possible test experiment,† "centrifugal force, so applied as alternately to assist and oppose the effects of gravity, as in large fly-wheels revolving with various degrees of rapidity." An arrangement of this kind is presented by the earth in its daily rotation, its centrifugal force being alternately added and opposed to the influence of solar attraction; and, from an examination of various recorded observations, I have deduced the following propositions:

* Phil. Mag. [4] 1, 68. My own belief in the correlation of motion, light, attraction, heat, electricity, and vitality, was first publicly announced in a lecture delivered before the Lyceums of Worcester and Lynn, Massachusetts, in the winter of 1844–5. During the two previous years, Mayer, Colding, Joule, and Grove, had published their first papers; but I am not aware that any report of their views had reached America.

If we regard mobility under its three necessary relations, we may, perhaps, advantageously group the elementary forces under the three heads of—

1. Influx: Gravitation, Affinity, Cohesion.
2. Immanence: Polarity, Electricity, Vitality.
3. Emission: Light, Heat, Actinism.

† Proc. Am. Phil. Soc. v. ix, p. 356.

I. The daily magnetic variations, though subject to great disturbances at different hours, show an average approximation to the differences of the gravitation-tidal currents.

II. Marked indications of an accelerating force are discoverable in the magnetic fluctuations, especially during the hours when the sun is above the horizon.

III. There are lunar-monthly barometric and magnetic tides, which may be explained by differences of weight or momentum,* occasioned by the combined influences of solar and lunar attraction and terrestrial rotation.

IV. The solar-diurnal variations of magnetism between noon and midnight (.00138), are nearly identical in amount with the variations of weight produced by solar attraction at the same hours (.00134).

V. The magnetic variations at intermediate hours between noon and midnight, indicate the influence of an accelerating force like that of gravity, modified by fluctuations of temperature and by atmospheric or æthereal currents.

VI. Some of the magnetic influences appear to be transmitted instantaneously, through the rapid pulsations of the kinetic æther,—others gradually, through the comparatively sluggish vibrations of the air.

VII. The comparative barometric disturbances of the sun and moon, exhibit an approximate mean proportionality between their comparative differential-tidal and magnetic disturbances.

VIII. The theoretical gravitation-variation of magnetism (Prop. IV) is slightly less, while the theoretical barometric-variation (Prop. VII) is slightly greater than the corresponding observed variation. The excess in one case exactly counterbalances the deficiency in the other, the sum of the theoretical being precisely equal to the sum of the observed variations.

IX. The total daily magnetic variations, like the barometric, can be resolved into a variety of special tides, which may be severally explained by well-known constant or variable current-producing and weight-disturbing forces.

X. The phenomena of magnetic storms indicate the existence of controlling laws analogous to those which regulate the normal fluctuations.

I propose briefly to substantiate these several propositions by a reference to the data on which they are based.

I.

The mere announcement of any new numerical relations between the effects of two great natural forces, like the first discovery of the inverse ratios of gravity and magnetism to the square of the distance, is curious and interesting, even if it should lead to no

* I believe there can be no weight without some degree of momentum. See Proc. A. P. S., vol. ix, p. 357.

ulterior results, and it may be reasonably supposed that such a ratio betokens a natural connection between the forces themselves. This hypothesis is greatly strengthened in the case now under consideration by the experimental illustrations that I have given of the influence of mechanical vibrations upon the magnetic needle (Proc. A. P. S., vol. ix, p. 359), and by the evident tendency of simple known causes to produce spiral eddies in the air and æther analogous to those which are constantly circulating around permanent magnets. (Ibid., pp. 367, sqq).* Having the elements of a mechanical polarity thus given, we might reasonably suppose that any excess of magnetic influence in one portion of the day would be balanced by a deficiency in some other portion, so that the average hourly differences would assume a tidal form, as stated in Prop. I. That such is the case is shown by

TABLE I. DAILY DIFFERENCES OF MAGNETIC FORCE.†

DIFFERENCES IN HUNDRED-THOUSANDTHS OF TOTAL FORCE.				RATIOS.		
Astronomical Time.	1 h.	2 h.	3 h.	1 h.	2 h.	3 h.
Before 3 h.	20	42	55	.364	.764	1
After 3 h.	20	39	55	.364	.709	1
Before 9 h.	5	15	26	.192	.577	1
After 9 h.	4	4	2	2.000	2.000	1
Before 15 h.	2	5	7	.286	.714	1
After 15 h.	1	2	4	.250	.500	1
Before 21 h.	31	54	66	.470	.818	1
After 21 h.	29	51	61	.475	.836	1
Means,	14	26.5	34.5	.406	.761	1
Mean of Ratios,				.563	.865	1

* The simplest of the three experiments referred to is performed with an ordinary binnacle compass. Holding the gimbals so as to allow motion in only one direction, and causing the box to swing like a pendulum, the needle will tend towards the line of oscillation, thus showing that simple mechanical vibrations can produce a species of polarity. If the combined action of convection and rotation upon the solar meridional currents, and on the temperature currents between the equator and the poles of greatest cold, be carefully studied, it will be seen that they furnish the elements of two sets of spiral eddies, or quasi-horizontal cyclones, in the air and æther, one flowing in a nearly constant direction along the magnetic meridian, and the other towards the momentarily shifting solar meridian. As the air has a certain degree of specific magnetism, the polarity which these eddies produce, may explain the directive energy of the compass needle.

† All of these tables are compiled from the St. Helena Observations and General Sabine's Discussions.

II.

TABLE II. SOLAR-DIURNAL VARIATION IN THE MAGNETIC FORCE AT ST. HELENA, IN HUNDRED-THOUSANDTHS OF THE TOTAL FORCE.

Time.	0 h.	1 h.	2 h.	3 h.	4 h.	5 h.	6 h.	7 h.	8 h.	9 h.	10 h.	11 h.
A. M.	—43	—41	—38	—36	—35	—34	—32	—20	+ 3	+34	+63	+85
P. M.	+95	+82	+60	+40	+20	+ 1	—15	—26	—36	—41	—45	—45

A simple inspection of the above table will furnish evidence of the truth of Prop. II. The relation of the magnetic to the tidal variations between 6 A. M. and 6 P. M. is more clearly shown by

TABLE III. HOURLY MAGNETIC DIFFERENCES DURING THE DAY HOURS.

	1st h.	2d h.	3d h.
Before 9 A. M., ...	31	23	12
After 9 A. M., ...	29	22	10
Before 3 P. M., ...	20	22	13
After 3 P. M., ...	20	19	16
	100	86	51
Tidal ratios, ...	100	73	27
Ratios of squares of mean magnetic differences, ...	100	74	26

For further illustrations, see the discussion of Prop. V.

III.

If we examine the position of the aerial rotation-spheroid, it will be seen that when the moon is approaching syzygy, at a distance of about 30°, in addition to the normal tidal action due to her situation relatively to the sun, she exerts a compressing force which tends to raise the daily average of the barometer, while, at the same distance before her quadrature, this secondary influence serves to increase the ellipticity and depress the barometric daily average. At intermediate points a portion of her attraction is employed in turning the aerial spheroid, thus producing a condensation of the air and elevation of the barometer, or a rarefaction and barometric depression, according as the spheroid is turned against the direction of the earth's rotation, or the contrary. Hence there result, besides the primary low barometer at syzygies, and high at quadratures, secondary low at 60° and 240°, secondary high at 150° and 330°, and tertiary high and low at some less definitely marked intermediate points. (Op. citat., p. 398.) I designate the tides as primary, secondary, and tertiary, not in the order of relative magnitude, but of stability and simplicity. The

currents produced by these disturbances apparently give rise to magnetic perturbations, which, although far less regular in their character than those of the barometer, furnish some indications of obedience to similar laws. (Ibid., pp. 434–8).

IV.

If any direct magnetic disturbance is occasioned by differences of gravitation towards the sun, it is reasonable to suppose that the instantaneous transmission of the gravitating force excites a magnetic current at the same instant in the æther. If M is the sun's mass and R its distance, its attraction is $M \div R^2 = 354936 \div 23000^2 = .00067$. Since this attractive force is added to that of the earth at midnight and subtracted at noon, the solar attraction-disturbance produces a daily difference in the tendency of a particle of air towards the earth's centre equivalent to .00134 of the total force. The solar-diurnal magnetic disturbance between the same hours, as shown by Table II, amounts to .00138 of the total force.

V.

Each particle of air may be considered as a planet revolving about the sun in an orbit that is modified by elasticity, terrestrial attraction, &c. In consequence of these disturbances, there is alternately a fall of twelve hours towards the sun between midnight and noon, and a rise from noon to midnight. From the nature of accelerating forces, the mean attraction-intensity disturbance should be found at $12^{h.} \div \sqrt{2} = 8^{h.}\ 29'$ from midnight, and, if my hypothesis of a connection between gravitation and magnetism is correct, the mean daily disturbance of magnetic intensity should take place at the same time. Such is very nearly the case, the morning mean occurring about $8^{h.}\ 44'$ after midnight, and the afternoon mean $8^{h.}\ 18'$ before midnight. The average daily mean is therefore $8^{h.}\ 31'$ from midnight, differing but $2'$ from the theoretical mean. The apparent retardation of $13'$, in consequence of inertia and rotation, will be referred to in discussing Props. VIII and IX.

During the intervals between the extremes and means, the æthereal currents and eddies are so variously affected as to render the task of precisely calculating either the particular values of the several disturbances, or their aggregate, extremely difficult, if not altogether impossible. We may, however, by a reference to the following table, easily discover some additional evidences of the dependent relation of magnetism to gravity. The theoretical variations are computed on the hypothesis that the magnetic differences vary as the square of the time, counting from midnight, the commencement of the fall. The barometric differences from the mean are given in ten-thousandths of an inch, the hourly thermometric differences in degrees of Fahrenheit.

TABLE IV. SOLAR-DIURNAL MAGNETIC, BAROMETRIC, AND THERMOMETRIC VARIATIONS AT ST. HELENA

Astronomical Time.	(A). Observed Magnetic Variations.	(C). Hourly Differences.	(B). Theoretical Magnetic Variations.	(D) Hourly Differences.	A—B.	C—D.	Observed Barometric Differences.	Hourly Thermometric Differences.
$0^{h.}$	+.00095	—.00013	+.00093	—.00021	+.00002	+.00008	+.0164	+.339
1	+.00082	—.00022	+.00072	—.00020	+.00010	—.00002	—.0002	+.215
2	+.00060	—.00020	+.00052	—.00018	+.00008	—.00002	— 0161	—.307
3	+.00040	— 00020	+.00034	—.00015	+.00006	—.00005	—.0268	—.531
4	+.00020	—.00019	+.00019	—.00014	+.00001	—.00005	—.0300	—.934
5	+.00001	—.00016	+.00005	—.00013	—.00004	—.00003	—.0259	—1.054
6	—.00015	—.00011	—.00008	—.00010	—.00007	—.00001	—.0179	—.717
7	—.00026	—.00010	—.00018	—.00008	—.00008	—.00002	—.0057	—.336
8	—.00036	—.00005	—.00026	—.00007	—.00010	+.00002	+.0078	—.239
9	—.00041	—.00004	—.00033	—.00004	—.00008	+.00000	+.0182	—.162
10	—.00045	.00000	—.00037	—.00003	—.00008	+.00003	+.0240	—.175
11	—.00045	+.00002	—.00040	—.00001	—.00005	+.00003	+.0204	—.161
12	—.00043	+.00002	—.00041	+.00001	—.00002	+.00001	+.0092	—.146
13	—.00041	+.00003	—.00040	+.00003	—.00001	+.00000	—·0044	—.182
14	—.00038	+.00002	—.00037	+.00004	—.00001	—.00002	—.0175	—.134
15	—.00036	+.00001	—.00033	+.00007	—.00003	—.00006	—.0259	—.089
16	—.00035	+.00001	—.00026	+.00008	—.00009	—.00007	—.0271	—.088
17	—.00034	+.00002	—.00018	+.00010	—.00016	—.00008	—.0210	—.027
18	—.00032	+.00012	—.00008	+.00013	—.00024	—.00001	—.0084	+.204
19	—.00020	+.00023	+.00005	+.00014	—.00025	+.00009	+.0077	+.707
20	+.00003	+.00031	+.00019	+.00015	—.00016	+.00016	+.0227	+1.117
21	+.00034	+.00029	+.00034	+.00018	—.00000	+.00011	+.0342	+.943
22	+.00063	+.00022	+.00052	+.00020	+.00011	+.00002	+.0363	+.943
23	+.00085	+.00010	+.00072	+.00021	+.00013	—.00011	+.0296	+.814

It therefore appears that

1. The night fluctuations of magnetic force (except during the four hours after sunset) are, as their supposed relations to gravity would lead us to expect, comparatively insignificant.

2. The magnetic influence of the atmospheric rotation-tide is perhaps shown by the convergence of the lines of equal magnetic disturbance near the hours of normal high barometer, and their divergence near the hours of low barometer. Thus, in the night, the difference of force is as great in the two hours between 9 and 11 P.M., as in the three hours between 2 and 5 A.M.; and in the day the difference in the three hours between 8 and 11 A.M. is two greater than in the four hours between 1 and 5 P.M.

3. The abnormal hourly differences (C—D) appear to be intimately connected with the barometric tides, having, like the latter, and at corresponding hours, two quarter-daily phases of excess and two of deficiency.

4. Not only do the times of mean baric and magnetic disturbance correspond very closely, as we have seen, but the observed hourly magnetic variation at the times of solar low-tide (6–7 A.M. and 6–7 P.M., allowing for the disturbance of rotation) is nearly the same as the theoretical variation (C—D = —1 in each instance).

5. In the hour immediately following the times of solar mean-tide ($3^{h.}$, $9^{h.}$, $15^{h.}$, and $21^{h.}$), the average theoretical and observed hourly differences are the same.

	3 P.M.	9 P.M.	3 A.M.	9 A.M.	Average.
C, ...	—20	—4	+1	+29	1.5
D, ...	—15	—4	+7	+18	1.5
C—D, ...	—5	0	—6	+11	0

6. If any further evidence were necessary to convince us that the barometric and magnetic disturbances are more directly dependent upon rotation, and the consequent continually changing position of each point of the earth's surface relatively to the sun, than upon mere changes of temperature,* it might be drawn from a comparison of columns 7, 8, and 9, in Table IV, or obtained by taking the half-daily barometric differences at each hour, as below:

	0 h.	1 h.	2 h.	3 h.	4 h.	5 h.	6 h.	7 h.	8 h.	9 h.	10 h.	11 h.
P.M., .	164	—2	—161	—268	—300	—259	—179	—57	78	182	240	204
A.M., .	92	—44	—175	—259	—271	—210	—84	77	227	342	363	296
	72	42	14	—9	—29	—49	—95	—134	—149	—160	—123	—92

* I speak here merely of the *disturbances*. The total force of terrestrial magnetism, according to my theory, is principally dependent upon the gravitation of temperature currents; but I think that the daily perturbations, both of the magnet and barometer, are determined almost entirely by changes of position consequent upon rotation.

VI.

The prompt disturbing action of the sun upon the magnetic needle was illustrated in the discussion of Prop. V. The slower operation of the moon may be inferred from the table of lunar-daily magnetic tides, attached to my communication of October 21, 1864 (Op. cit., p. 433). The retardation of the barometric action will become evident from the discussion of the three following propositions.

VII.

Since the solar and lunar currents are mainly determined by differences of gravitating force, either under the form of differences of pressure or of tidal flow, it seems very probable that the ratio of the barometric to the magnetic disturbance of each luminary may be some function of the relative barometrical and tidal effects of the two bodies. This hypothesis is confirmed by the fact that the lunar-diurnal variations, both of the magnet and of the barometer, exhibit two high and two low daily tides, while the solar-diurnal magnetic variation, like the temperature-tide of the barometer, has only one maximum and one minimum in twenty-four hours.

Let $A' =$ the solar-differential tidal force.

$B' =$ the diurnal barometric variation.

$M' =$ the diurnal magnetic variation.

Let A'', B'', M'' represent the corresponding lunar elements.

If the modern physical hypotheses are correct, and the forces that produce A, B, and M, are all forms of motion, it is probable that some simple relationship may exist between them. In endeavoring to ascertain that relationship, we readily discover that

$$A' < A''$$
$$B' < M'$$
$$B' > B''$$
$$B'' > M''.$$

These inequalities, together with the fact that the solar currents are developed in air that is disturbed by the greater attractive energy of the moon, and the lunar currents in air that is disturbed by the more powerful barometric action of the sun, suggest the following hypothetical equivalent proportions:

$$B' : B'' :: \surd\overline{A'\ M'} : \surd\overline{A''\ M''}$$
$$A' : A'' :: B'^2\ M'' : B''^2\ M'$$
$$M' : M'' :: B'^2\ A'' : B''^2\ A'.$$

From the same considerations we may readily infer a probability that

$$\frac{B'}{M'} = \frac{A'}{A''} \qquad (1)$$

$$\frac{B''}{M''} = \frac{B'}{B''} \qquad (2)$$

and that, therefore, B″ is a mean proportional between B′ and M″. From these equations the foregoing proportions may be reproduced by dividing (1) by (2), and multiplying the quotient by the identical equation $\frac{B'}{B''} = \frac{B'}{B''}$

According to Major-General Sabine's tables (St. Helena Obs., v. ii, p. lxi), there is a solar maximum, measured in parts of the total force, of +.00095 at noon, and a solar minimum of —.00045 at 11 P.M.:

$$\therefore \qquad M' = .0014 \qquad (3)$$

The lunar tide is so modified by rotation that its true value can perhaps be best ascertained by adding the tides at equal distances from the lunar meridian (Ibid., p. lxii), and taking their average.

LUNAR-DIURNAL MAGNETIC VARIATION IN MILLIONTHS OF THE TOTAL FORCE.

	0 h.	1 h.	2 h.	3 h.	4 h.	5 h.	6 h.	7 h.	8 h.	9 h.	10 h.	11 h.	12 h.
Before Lunar M.,	+5	—1	+4	—2	—5	—5	—6	—3	—2	—1	+14	+15	+16
After Lunar M.,	+5	—1	—5	—6	—7	—6	+1	+1	—2	+18	+25	+22	+16
Mean Tide,	+5	—1	—.5	—4	—6	—5.5	—2.5	—1	—2	+8.5	+19.5	+18.5	+16

We thus obtain an average low tide of —.000006 at 4 h., and a high tide of +.0000195 at 10 h., which gives

$$M'' = .0000255 \qquad (4)$$

The values of B′ and B″, as deduced from the tables presented at the meeting of July 15, 1864 (Proc. A. P. S., v. ix, pp. 406, 409), are

$$B' = .016 \text{ in.} \qquad (5)$$

$$B'' = .00365 \text{ in.} \qquad (6)$$

Dividing by 28.2821, the mean height of the barometer, in order to obtain results in terms of the total barometric pressure, we have

$$B' = .00056573 \qquad (7)$$

$$B'' = .0001291 \qquad (8)$$

The relative values of A′ and A″ have never been precisely determined. Probably the

latest and most correct estimate is the one given in the New American Cyclopedia, article "Tides," according to which, if we assume

$$KA' = 1 \qquad (9)$$
$$KA'' = 2.55 \qquad (10)$$

Of the homologous quantities contained in (1) (2), it is fairly presumable that those of the greatest magnitude (B′, M′) have been most precisely estimated. Assuming their accuracy, we have

1. If (8) be supposed correct,

$$M'' = .00002944 \qquad (11)$$
$$\frac{A'}{A''} = \frac{1}{2.475} \qquad (12)$$

2. If (4) be supposed correct,

$$B'' = .00012 \qquad (13)$$
$$\frac{A'}{A''} = \frac{1}{2.475} \qquad (14)$$

3. If M′ and B″ are required, (4), (9), and (10) being supposed correct,

$$M' = .00144 \qquad (15)$$

and the value of B″ is the same as in (13).

Other hypotheses might be made, but these are sufficient for illustration. Even the widest discrepancy between theory and observation is much less than might have been reasonably anticipated in measurements of such extreme delicacy, and far within the limits of probable error, as will be seen by the following synopsis:

	KA′	KA″	B′	B″	M′	M″
Observed,	1	2.55	.00057	.00013	.0014	.0000255
Theoretical, 1	1	2.475	.00057	.00013	.0014	.0000294
Theoretical, 2	1	2.475	.00057	.00012	.0014	.0000255
Theoretical, 3	1	2.55	.00057	.00012	.00144	.0000255

In regard to the first theoretical value of M″, it may be observed that it is very nearly equivalent to the mean between .000032, the extreme excursion of the lunar tide, and .0000255, the mean tide.

It is evident that M′ and M″ are theoretically affected only by the *ratio*, and are independent of the specific magnitudes of A′ and A″. Still the following determination of the values that satisfy the hypothetical formula $B = \sqrt{AM}$, may, perhaps, be interesting:

	Observ.	Theor. 1.	Theor. 2.	Theor. 3.
K	4374	4374	4374	4499
A′	.000229	.000229	.000229	.000222
A″	.000653	.000566	.000565	.000565

These several determinations of K approximate to the square of the ratio of the velocity of rotation to the velocity of revolution ($92000000 \div \overline{3963 \times 365.25} = \surd\overline{4040}$), and to the ratio of the terrestrial to the atmospheric density, and suggest the propriety of considering the element of density (or of its correlative, the square of the time of molecular diffusion), in connection with both A and M.

The value of A′ is nearly a mean proportional between the earth's attraction-intensity and the sun's differential-tidal attraction ($\surd\overline{2M \div R^3} = \surd\overline{709872 \div 23000^3} = .000242$).

The ratio of M′ to M″ approximates to the compound ratio of the solar and lunar attraction-intensities and their differential attractions.

VIII.

The theoretical determination of M′ from the joint-consideration of the maxima of the tidal disturbances of equilibrium and the barometric variations (according to the third hypothesis in Prop. VII), is .00144, which is .00004 greater than the extreme observed range of the solar-diurnal magnetic fluctuations. The determination of the same element from the simple consideration of the solar attraction (Prop. IV), was .00134, which is .00004 less than the observed difference of magnetic intensity between the hours of greatest and least attraction. The sum of the two theoretical is precisely equal to the sum of the two observed variations, a result which tends to confirm the opinion that all the disturbances which are attributable to differences of gravitating force, whether initiated by tidal differences, differences of temperature, or rotation, all tend to produce perturbations of magnetic force.

The following comparison appears to show that whatever indirect influence may be exerted upon the magnet by the regular barometric variations, being communicated through the aerial vibrations, is retarded by atmospheric inertia:

	Max.	Min.	Greatest Half Daily Fluctuations.	Least Half Daily Fluctuations.
Barometric pressure, ...	22 h.	4 h.	9—21 h.	3—15 h.
Magnetic force, ...	0 h.	10—11 h.	0—12 h.	7—19 h.
Difference of time, ...	2 h.	6 h.	3 h.	4 h.

IX.

Some evidences of special tidal division have already been given; others may be found in a combination of the morning and evening fluctuations, and an examination of the means, as in

TABLE V. DAILY MAGNETIC TIDES, THEORETICAL AND OBSERVED.

Hours from Midnight.	Theoretical Gravitation Tide (A).	Theoretical Differential Solar Tide (B).	(A + B)* Theoretical Mean Tide (C).	Observed Mean Tide (D).	Difference (C—D).	Rotation Tide.
0	—.00067	+.00024	—.00043	—.00043	.00000	
1	—.00058	+.00021	—.00037	—.00043	—.00006	±.00002†
2	—.00050¼	+.00012	—.00038¼	—.00041½	—.00003¼	±.00003½
3	—.00033½	.00000	—.00033½	—.00038½	—.00005	±.00002½
4	—.00016¾	—.00012	—.00028¾	—.00035½	—.00006¾	±.00001½
5	—.00009	—.00021	—.00030	—.00030	.00000	∓.00004
6	.00000	—.00024	—.00024	—.00023½	+.00001½	∓.00008½
7	+.00009	—.00021	—.00012	—.00009½	+.00002½	∓.00010½
8	+.00016¾	—.00012	+.00004¾	+.00011½	+.00006¾	∓.00008½
9	+.00033½	.00000	+.00033½	+.00037	+.00003½	∓.00003
10	+.00050¼	+.00012	+.00062¼	+.00061½	—.00000¾	±.00001½
11	+.00058	+.00021	+.00079	+.00083½	+.00004½	±.00001½
12	+.00067	+.00024	+.00091	+.00095	+.00004	

Column A contains the hourly differences from mean weight attributable to solar gravitation, with changed signs,—diminution of weight being accompanied with increase of magnetism, and *vice versâ*.

The form of the tide in column B is evidently such as should be determined by solar action. The magnitude of the tide is estimated by comparing the relative amounts of motion down the diagonal and down the arc of a quadrant ($.00067\times[1-(\frac{\pi}{4}-\frac{1}{2})]=.00048$). The mean-tidal difference [(.00067—.00048)÷2] is very nearly equivalent to the average theoretical inertia-disturbance of weight. The atmospheric inertia at St. Helena (regarding the fluctuations as uniform between two successive hourly observations), produces retardations of 59′, 85′, 26′ and 31′, at 0^h, 6^h, 12^h, and 18^h, respectively. The mean retardation is 50′, or $\frac{5}{7}\frac{0}{2}$ of a half-day. The daily gravity-variation being .00134, the average variation in $\frac{5}{7}\frac{0}{2}$ of a half-day is .00009 $\frac{1}{3}\frac{1}{6}$, the mean-tidal difference being 00009½.

The signs of the differences (C—D) are apparently determined, as in column A, by the variations of weight; the magnitude, partly by the differences of pressure in the corres-

* Compare Secchi's Third Law, Phil. Mag. [4], 8, 396.

† The upper signs are for the morning, the lower for the evening hours.

ponding day and night hours, and partly by differences of temperature. The sum of the positive is precisely equal to the sum of the negative differences.

The rotation-tide is the residual difference between the observed mean tide and the actual magnetic force. Its relation to the barometric rotation-tide is shown by the signs, which are positive when the diminution of barometric pressure is in the direction of the earth's rotation, and negative when the pressure is increasing in that direction.

The consideration of the moon's disturbance of the atmospheric gravitation is complicated by the magnitude of its differential attraction, the position of the centre of gravity of the terrestrial system, the varying centrifugal force, and other circumstances involved in the lunar theory. Still there are indications, in the following synopsis, of the influence of gravity, sufficiently striking to encourage a hope that our knowledge of the moon's perturbations may be improved by a thorough comparative study of the lunar astronomical, atmospheric, and magnetic tables.

TABLE VI. LUNAR-DAILY DISTURBANCES OF MAGNETIC FORCE AT ST. HELENA, IN MILLIONTHS OF THE TOTAL FORCE.

Hours, ...	0	1	2	3	4	5	6	7	8	9	10	11	12
Before Lunar M., . .	+5	—1	+4	—2	—5	—5	—6	—3	—2	—1	+14	+15	+16
After Lunar M., . .	+5	—1	—5	—6	—7	—6	+1	+1	—2	+18	+25	+22	+16
Mean, ...	+5	—1	—0.5	—4	—6	—5.5	—2.5	—1	—2	+8.5	+19.5	+18.5	+16
Rotation-Tide, . . .	0	0	±4.5	±2	±1	±.5	∓3.5	∓2	0	∓9.5	∓5.5	∓3.5	0

The above table shows that—

1. The moon's attractive force ($M \div R^2 = .016 \div 60^2 = .000004\dot{}$), multiplied by the coefficient of its differential attraction (2.55), gives $.0000113\dot{}$, which is nearly the same as the mean meridional magnetic disturbance [$(.000005 + .000016) \div 2 = .0000105$].

2. The increase of magnetism at $12^{h.}$ is nearly equivalent to the attractive force, multiplied by the square of the distance from the centre of gravity of the system, and divided by the square of the earth's radius ($.000004\dot{} + 7707^2 \div 3963^2 = .0000168$).

3. There is a tendency to equality of disturbance on each side of the meridian, at $1^{h.}$ and $8^{h.}$, as in the solar magnetic tide.

4. The greatest disturbance occurs at the hours of $10^{h.}$ and $11^{h.}$ P.M., both in the solar and in the lunar tide.

5. There are some indications of an increase of gravity and decrease of magnetic force when the tidal flow is towards the centre of gravity of the terrestrial system, and *vice versâ*.

6. The rotation-tide has the customary quarter-daily phases of alternate increase and diminution.

X.

In consequence of the cumulative tendency of partially obstructed waves, as illustrated in the ocean tides, and in the occasional great breakers on a beach, the atmospheric currents are liable to disturbances, which, according to my theory, should produce the phenomena known as "magnetic storms." Since the normal action which we have been considering requires the employment of a constant portion of the magnetic force, the aggregate excess should also be constant, and should therefore present analogous numerical relations.

Mr. Airy, the British Astronomer Royal, has published a paper,* in which he presents the sums and coefficients of magnetic irregularities, deduced from a long series of observations. His aggregates appear to indicate that the disturbing force is a third proportional to two other forces, which may be called, respectively, central and tangential.

Thus in his "Table II, Algebraic Sums of Magnetic Fluctuations (in terms of Horizontal Force) for each Year, from 1841 to 1857, including all Days of Record of Great Magnetical Disturbance," the Mean Disturbance is

Westerly Force.	Northerly Force.	Nadir Force.
—.00023 = M.	—.00146 = T.	—.00057 = C.

Here the proportion T : C : : C : M gives for M a

Theoretical value, ...	—.000222
Observed "	—.000228

"Table III. Algebraic Sums of Magnetic Fluctuations (in terms of Horizontal Force) for each Year, from 1841 to 1857, including only those days of Great Magnetic Disturbance, in which Records were made by the three Instruments."

Theoretical value of M, ...	—.000287
Observed " "	—.000257

"Table VIII. Sums, without regard of sign, of Coefficients of Magnetic Irregularity (in terms of Horizontal Force) for each Year, from 1841 to 1857, including all Days of Record of Great Magnetical Disturbance." The proportion C : T : : T : M gives for M a

Theoretical value, ...	.001218
Observed "	.001203

"Table IX. Sums, without regard of sign, of Coefficients of Magnetic Irregularity (in

* "First Analysis of One Hundred and Seventy-seven Magnetic Storms, registered by the Magnetic Instruments in the Royal Observatory, Greenwich, from 1841 to 1857. By GEORGE BIDDELL AIRY, Astronomer Royal."—*Trans. Royal Soc.*, Vol. 153, Art. XXIX.

terms of Horizontal Force) for each Year, from 1841 to 1857, including only those Days of Great Magnetic Disturbance, in which Records were made by the three Instruments."

Theoretical value of M, ...	.001137
Observed " "	.001150

The "Westerly Force" I regard as representing the permanent magnetic force produced by the constant flow of currents between each point of the isothermal equator and the poles of greatest cold; the "Northerly" and "Nadir" forces as the tendencies towards the solar meridian, and towards or from the earth's centre, produced by the diurnal solar wave. This assignment appears to be justified by Mr. Airy's observation, that "the Aggregate for the Westerly Force . . . . (taken in comparison with that for the Northerly Force), appears to show that, on the whole, the direction of the Disturbing Force is 10° to the east of south;" p. 628. This indicates a line of mean disturbance about midway between the magnetic meridian (which, at London, is about N. 24° W.), and the solar meridian, or midway between the meridians of decussation in the two sets of principal spirals, to which I have referred.

The law of varying attraction suggests a plausible explanation for the approximate mean proportionality of the barometric to the tidal and magnetic variations. For the ratios of attraction of any planet when in solar conjunction, at quadrature, and in opposition, vary as $(n+1)^2$, n^2, and $(n-1)^2$, respectively, the attraction at the mean distance being nearly a mean proportional between the maximum and minimum attractions. The barometric fluctuations are occasioned by variations in the gravitation of the air towards the earth's centre,—the tidal motions, by the influence of distant heavenly bodies,—and the magnetic, according to my hypothesis, by the oscillations of the air and æther in their efforts to restore the unsettled equilibrium. The three disturbances, therefore, must evidently have nearly the same mutual relations as if they were produced by three forces, one centripetal, and the other two centrifugal, the two latter being nearly equal in amount but diametrically opposed in direction.

In our discussion of Prop. V, we found some indications of a lagging of about 13′ in the time of the magnetic mean disturbance, which is about one-fourth of the average barometric retardation. This corresponds very nearly with the ratio of the lunar-barometric to the lunar-magnetic disturbance (4.384), and with Mr. Welsh's determination of the moment of magnetic inertia (4.4696; Phil. Trans., v. 153, p. 297).

The foregoing comparisons have been based almost exclusively on Major-General Sabine's discussions of the St. Helena records. It would be desirable, if it were possible, to confirm them by observations at other stations near the equator; but the need of such confirmation is in great measure obviated, by the variety of ways in which I have shown the

probable connection of gravity and magnetism. At extra-tropical posts, the rotation-tide becomes so preponderating that it is difficult to trace the diminished gravitation- and differential-tides, or to discover any obvious numerical relations between the two great forces. Still, the direction of the gravitating force furnishes so satisfactory an explanation of some of the incidental phenomena of magnetic variation, that I am induced to extend my paper somewhat, in order to direct attention to a field of research in which I believe physicists may reasonably hope to obtain encouraging quantitative results.

Among the pointings to unity of force which have led me to this belief, and have strengthened my conviction that terrestrial magnetism is a simple reaction against disturbances of terrestrial gravitation, are the following: Ampère's discovery of the magnetic effect of electric currents circulating around iron bars; Arago's experiments (which were repeated and extended by Babbage, Herschel, Barlow, Christie, and others), showing that simple rotation produces magnetic disturbances which are governed by fixed laws; the distribution of induced magnetism in masses of iron, which, as I announced at the Society's meeting of April 15, 1864, is the same as would follow from the relative centrifugal motions of different portions of the earth, provided the magnetic axis corresponded with the axis of rotation; Hansteen's suspicion, confirmed by Sabine's practical demonstration* of the influence of the sun upon terrestrial magnetism; Secchi's discovery that "the diurnal excursion of the needle is the sum of two distinct excursions, of which the first depends solely on the horary angle, and the second depends, besides, on the sun's declination,"† and that "all the phenomena hitherto known of the diurnal magnetic variations may be explained by supposing that the sun acts upon the earth as a very powerful magnet at a great distance;"‡ Captain Ross's observations upon the effect of barometric fluctuations on the ocean-level (Proc. Roy. Soc., June 15, 1854);§ Mr. Ferrel's paper on the disturbance of barometric pressure by centrifugal force and friction (Nashville Journal of Medicine and Surgery, 1856, and Mathematical Monthly for 1859, vol. 1, p. 140, sqq.);‖ and the various other considerations which I have hitherto adduced in support of my views regarding the connection of rotation with aerial and ætherial currents, and with baric or magnetic perturbations.

The hypothesis that the sun has a specific magnetism, which acts upon the earth by simple induction, like the earlier ones, which attributed terrestrial magnetism to one or

* In his discussions of the observations at Toronto, Hobarton, and St. Helena.

† Phil. Mag. [4] 8, 396. ‡ Ibid. 9, 452. § Ibid. 8, 318.

‖ I am glad to learn that Mr. Ferrel has resumed his investigations with special reference to a fuller development of the theory of tidal action, and I have a confident hope that his researches will give us a clearer understanding of the phenomena of magnetic, as well as of oceanic tides.

more powerful magnets, lying nearly in the line of the earth's axis, has been objected to on the ground that it is difficult to understand how any conceivable magnetic intensity, by its simple induction, could produce so great a disturbance as is daily observed.* But if Barlow's theory—that the magnetism is superficial—is correct,† and the reasonable grounds which have led to its general adoption have never been controverted, his idea that it is also in some manner induced, must be regarded as extremely probable. The arguments that have been plausibly urged against an induction analogous to that which takes place between ordinary magnets, have no weight if the inducing force is simple gravitation, and the induced effect is a simple reaction. From the fact that magnetism, like gravity, is a central force, varying inversely as the square of the distance, Secchi's conclusions derive a new interest, and lend encouragement to those who are endeavoring to find additional evidences of kinetic unity.

The daily magnetic variations corresponding, as has been shown, both in character and amount, with the variations of gravitating force, the question may naturally arise, whether a like correspondence can be found in the annual and secular changes. The unknown meteorological agency which is gradually shifting the isothermal lines on which I have supposed the terrestrial magnetism primarily to depend, the want of a sufficiently precise determination of the monthly and annual perturbation-values, and the variety of elements (many of which are still undetermined) that should enter into our equations, render it impossible at present to arrive at quantitative results, but the evidence of a qualitative correspondence is most satisfactory.

Among the conclusions which General Sabine has deduced from his discussions are the following:

1. "That the easterly and westerly disturbances have different hours for their principal development,—that these hours differ most widely in different parts of the globe,—and that we may already perceive some indications of a connection existing between the epochs of greatest development and differences of geographical longitude." (St. Helena Obs., Vol. II, p. cxvii.)

2. "The evidence afforded by each of the three observational elements in regard to annual variation is to one and the same effect. January and June are the months of minimum disturbance; September and April the months of maximum disturbance. The aggregate value of the disturbances in the equinoctial months is about three times as great as in the solstitial months. Of the two equinoctial months, the value is somewhat higher in each element in September than in April; and of the two solstitial months, December is higher than June, also, in each of the three elements." (Toronto Obs., Vol. III, p. lxx.)

* See, inter alia, Phil. Mag. [4] 15, 192 and 27, 384.

† Phil. Transactions, 1831.

3. At Toronto, "in both elements, when the relative proportions are taken,—in the Declination of the aggregate values, in the different months, of easterly and of westerly disturbances; and, in the Vertical Force, of disturbances which decrease and disturbances which increase the force, we find that in both cases the proportions vary from a minimum at the southern solstice to a maximum at the northern solstice, the equinoxes being intermediate. . . . . The relative proportion of the aggregate values of easterly to westerly disturbances of the Declination, and of disturbances which decrease the Vertical Force to those which increase it, varies from one solstice to the other, approximately, as three to one, and in both elements nearly alike." (Ibid. p. lxxi.)

The first of the above inferences is in precise accordance with the theory that the permanent magnetism of the globe is owing to the gravitation of the thermal currents, which are constantly flowing between the thermal equator and the poles of greatest cold.

The second inference presents two points of interest, each of which has been specially noticed by General Sabine. The first is the increase of disturbances as the earth approaches the sun; the second, the relation of the disturbances to the sun's declination, which is precisely such as my hypothesis would indicate. For, at the equinoxes, the action of solar attraction being in the plane of the earth's rotation, the disturbance-spheroid is of course a maximum; while, at the solstices, the planes diverge most widely, and the spheroid is therefore a minimum.

The third inference is likewise confirmatory of my views, since it shows that in the annual, as well as in the daily perturbations, increasing solar altitude, which increases gravitation-disturbance, also increases magnetic disturbance. The equality of the ratios in the second and third inferences is also noteworthy.

The various coincidences which I have thus brought together, present, to my mind, new and convincing evidence of that unity of force which was one of the earliest tenets of speculative philosophy, but which has only recently been brought within the domain of physical science. The doctrine was taught explicitly by Leucippus and Democritus, and, before their day, by the priests of Isis and Osiris; but its practical demonstration was inaugurated by our own countryman, Benjamin Thompson, Count Rumford, and has been successfully prosecuted by Carnot, Seguin, Mayer, Colding, Joule, Grove, and the daily increasing corps of their collaborators. Through their labors a new impetus has been given to the study of natural philosophy, and we may even be pardoned for indulging the hope, that an increased knowledge of the laws and correlations of force, may lead us to a clearer understanding of the nature of Intelligence, to which all force is subject and subordinate.

NOTE.

The following extracts show that Secchi's hypothesis of solar magnetic induction was only provisional, and that a fuller report than has yet been published of the details of his investigations is greatly to be desired.

"We, too, in the same spirit, and merely for the purpose, if possible, of combining facts, have supposed the sun to act as a great magnet. The explanations hitherto proposed may be reduced either to thermo-electric currents induced by the sun in the different strata of the earth, or to the electricity developed in the meteorological changes of which the sun is the principal cause. A single reflection seems to exclude these from being *principal* causes of the magnetic diurnal period. The characteristic fact, as we have already noticed, is that the magnetic elements have a double period, diurnal and nocturnal. . . . .

"To this proof in support of the solar magnetic theory, may be added another, already noticed by General Sabine, and worked out by us in § 1 of Part II of this memoir, viz., the opposite action of the sun according to its declination, the inversion occurring exactly at the epoch of the equinoxes; and here another difference will be seen between the effects of thermical and meteorological causes and the magnetic effect of the sun. The former do not reach their extremes for a considerable time after the corresponding astronomical phases, while the latter have an almost exact coincidence with them. . . . . .

"We do not pretend, however, that there are not considerable difficulties in the way of this hypothesis; and although it explains very well certain very singular facts,—as, for example, the interval of six hours between the diurnal maxima and minima, a fact the explanation of which has never, as far as I am aware, been even attempted on any other hypothesis, and which yet is so marked in all the magnetic variations in the mean latitudes; also, the singular exception which it suffers at the equator, becoming simple for the horizontal and for the vertical components, and various other points,—yet we must confess that there are some irregularities which our formulæ do not explain. Of this nature is the fact, that at St. Helena, and generally under the equator, the period for the declination of the needle appears to be rather eight hours than twelve, so that it presents sometimes three maxima. . . . . .

"The fact mentioned above, that the maxima of the perturbations at Hobarton succeed each other with the same retardation as the other magnetic phases, is one which cannot be explained either by the retardation of the effect of temperatures, or by the condensation of vapor. We cannot conceive how these should account for the general retardation of one hour. It is then a purely magnetic fact, the explanation of which depends on that of the physical cause of solar and terrestrial magnetism. The same may be said of the

greater perturbations at the epochs of the equinoxes, which certainly bear no relation to the state of the atmosphere or to the solar heat. . . . . .

"A hypothesis, however, can be found which would conciliate the various facts, viz., that atmospheric changes may generate electricity; but that the direction of the current, which of itself would be indeterminate, may be determined by the magnetic action of the sun. But to expand this further into a hypothesis would be at present premature. We will only say that it is not improbable that the earth is subject to the magnetic action of the sun in a manner unknown to us; but now that magnetic phenomena are developing themselves under so many aspects, we may hope that the explanation of these mysterious actions will soon be found." [Phil. Mag., 4th ser., vol. ix, p. 441 to 450.]

I can already discover, in the gravitation of the various currents which I have pointed out, an explanation, satisfactory to my own mind, of all the phenomena here referred to; but numerous special and novel observations are desirable before attempting any further development of my views.

ARTICLE VII.

THE MYRIAPODA OF NORTH AMERICA.*

BY H. C. WOOD, JR., M.D.

Read June 16, 1865.†

The Myriapoda are air-breathing apterous articulata characterized by the distinctness of the head from the body; the strongly marked segmentation of the latter, and its method of development.

The head varies very much in size and the perfection of its organization, but is always separate and distinct. The organs of special sense are very well developed in all but the lowest orders. The eyes are in one family compound, in the others stemmatous and single or numerous, or else entirely wanting.

The body is composed of a varying number of segments, most of which are merely a repetition of the preceding. The number varies from sixteen to several hundred. As a general rule, the fewer the segments the higher the organization. Each perfected segment is formed from two subsegments, either by their coalescence and mutual growth, or

* Most of the material on which this paper is founded has been furnished by the Smithsonian Institute, Museum of Comparative Anatomy and Zoology of Cambridge, and the Academy of Natural Sciences of Philadelphia. By far the larger portion was received from the Smithsonian, much of which was collected by Mr. Kennicott in South Illinois, and R. J. Walker in Western Pennsylvania. The latter gentleman sent some seven or eight thousand specimens. Prof. Manly Miles, of the State Agricultural College of Michigan, also furnished several new species from that State. I have also examined a small collection of Canadian Myriapoda, received from Prof. Dawson, of Montreal.

In "North America," Mexico is not intended to be included, since although perhaps geographically it is a part of the latter, yet its Fauna is much more closely allied to that of Central than North America. The monograph was originally commenced at the suggestion of Prof. Baird, some four years ago, to form part of the Miscellaneous Collections of the Smithsonian Institute, and the wood-cuts have been executed at the expense of the Institution. As the publication of this series has been temporarily suspended, with the consent of Prof. Henry the paper was offered to the Philosophical Society. The wood-cuts were drawn by Mr. Edward J. Nolan, under my personal supervision, and every effort has been made to have them entirely accurate.

† The original MS. of this memoir was presented to the Smithsonian Institute, and destroyed in the conflagration of part of the Smithsonian building in the winter of 1864–5. It was then rewritten and presented for publication to the A. P. S. by the author, with the permission of the Secretary of the S. I., who granted likewise the use of such wood-cuts as were already either drawn or executed, about 60 in all. [Sec. A. P. S.]

by the atrophy of one and the hypertrophy of the other. The dorsal and ventral portions of the subsegments are each formed originally from four pieces. The two central unite very early in the embryo, and completely fusing form the primitive scuta and sterna, with which the outer pieces, the episcuta and episterna, unite sooner or later. Well-pronounced grooves or sutures in the adult frequently indicate the point of union between the epi and primitive sterna, the epi and primitive scuta. A typical or ideal segmental arc (Fig. 1) would therefore be formed by the conjunction and coalescence on the dorsal surface of four pieces, and of the same number on the ventral aspect: *i. e.*, two primitive scuta (Fig. 1, *b*), each with its episcutum (Fig. 1, *a*); and two primitive sterna (Fig. 1, *c*), each with its episternum (Fig. 1, *d*). To the upper or dorsal portion pertains the organs of vegetative life: *i. e.*, the circulatory and secretory apparatuses; to the lower or ventral portion the organs of animal life, the nervous system.

Fig. 1.



In this typical segmental arc the perfected scutum and sternum do not coalesce, nor do they even approximate and unite by suture, but are connected by a strong flexible integument. This membrane is divisible into two regions, the upper of which is subsidiary to the scutum, the lower to the sternum. Now, it is in this portion of the segmental arc that the appendages are formed, a sternal and scutal pair to each subsegment. On the examination of a Scolopendra, some little plates will be found situated on the lateral membrane, just anterior to the spiracles. These are the rudiments of the scutal appendages, which are never more highly developed in the Myriapoda. The normal scutal appendages of an articulate are wings, whose points of origin in the hexapoda correspond to these plates. Of course, then, in apterous articulates they cannot be developed. The sternal appendages are the organs of locomotion, the legs. To sum up, a typical myriapodal segment is formed from two subsegments, each of which is originally formed from eight pieces, and is composed of a dorsal and ventral arc, united by a membrane, and furnished with a single pair of appendages.

The *existent* myriapodal segments follow two structural plans or types, modifications of the typical or ideal. These constitute the two great orders, the Chilopoda and the Diplopoda. In the first of these, the anterior subsegment is so atrophied that it really forms no part of the perfected whole. Its appendages are entirely lost; indeed, its only representatives are some small plates, situated on the ventral surface just anterior to the sterna. On the other hand, the posterior subsegment, with its appendages, is developed to the highest degree, and equally, or nearly equally so, in all its parts, neither the ventral nor dorsal portion of the arc predominating. So in a Chilopod there are large sterna and scuta, sepa-

rate from one another, but connected by a lateral membrane, and each segment is furnished with a single pair of large legs.

In the Diplopoda, one subsegment is not thus developed at the expense of the other, but, the two coalescing, the perfected whole is obtained by their mutual growth. There are therefore two sets of appendages, two pairs of legs, to each segment. The dorsal or vegetative portion of each subsegment is, moreover, developed much more highly than the ventral or neural arc. Indeed, the scuta completely absorb the lateral membranes, and abut directly against the sterna. These latter are always more or less atrophied, and, their appendages partaking of their stunted growth, the legs are much smaller than in the Chilopoda. The excess of the vegetative systems point to a position below the Chilopoda, an indication which all the other minor facts corroborate. An examination of the Chilopoda shows that as the scale is descended the number of segments increases, the rudiments of the anterior subsegments become more and more pronounced, and the legs smaller and smaller, thus approaching the diplopod type.

In the Diplopoda the genital apertures are placed in the anterior portion of the body, and, as far as I have examined, always furnished with more or less prominent organs; whilst in the Chilopoda they are placed in the posterior portion of the body, and very generally not so provided. There is also a great and persistent difference in the appearance of the anal aperture in the two orders.

The whole organization of the Chilopods fits them for their predatory and carnivorous habits. The distinctness of the segments, which are not closely approximated, but are conjoined by membranes, and the flexibility of the segments themselves, enable them to move their bodies in every conceivable direction. Their highly organized muscular and nervous systems, the compactness of their intestinal apparatus, and the length and power of their legs, all betoken habits of great activity. Whilst the formidable nature of their mandibles, and the sharp spines, both lateral and terminal, with which their feet are armed, fit them for predatory warfare.

There can be no doubt but that they are provided with poison glands situated at the base of the mandibular teeth, and perhaps also at the bases of the terminal claws of the feet. I remember once to have been bitten by a female Scolopocryptops sexspinosa, who was trying to defend her young. Though of such insignificant size, when compared with the tropical Scolopendra, yet the pain produced lasted for several hours. It is therefore easily to be imagined that the huge species, a foot in length and inch in breadth, found in the tropics, have the power of doing considerable mischief. I have been informed by a resident of Texas, that minute ulcers follow the wounds made by the feet of S. heros on the skin.

The Diplopods depend upon the vegetable kingdom for their sustenance. The body is

much more rigid than in the Chilopods, from the close conjunction, or often imbrication, of the segments, and the inflexibility of the segments themselves, caused by the density and thickness of the scuta aud sterna and the absence of lateral membranes. For this reason the Diplopoda possess but little or none of that power of raising and twisting the body, which is so annoying to the collector of tropical Scolopendra. The poorly developed nervous system and organs of special sense, the short weak legs, and the weak muscular and large intestinal development, all point to the vegetable nature of the food of this order and the associated sluggish habits, which indications the total absence of offensive armature confirms.

M. Brandt (Recueil) divided the Myriapoda into *Myriapoda manducentia* and *Myriapoda sugentia.* The former comprises all those which are provided with mandibles or jaws for seizing or devouring food. The latter, the few centipedes which have the different pieces about the mouth so united and consolidated as to form a tubule, fitted for the ingestion of liquid food. Although this classification has emanated from such an authority, yet it seems apparent that it does not agree with nature, and must be abandoned. Still, it has seemed to me that in doing this Mr. Newport and others have not allowed these characters the weight that they deserve. Mr. Gray does not even allow them generic force, if his classification (Cyclop. Anat. and Physiol., art. Myriap.) is to be trusted. Or was he entirely ignorant of their existence! Newport gives to them a family significance.

The different structure of the mouth, and the consequent different food and habits of living, although not sufficient to stand in competition with the characters separating the Chilopoda and Diplopoda, are still of higher import than any other differences in the latter order. I have therefore divided the Diplopoda into two suborders, the *Chilognatha* and *Sugentia*, retaining old names, but giving new significance to them. The minor characters have seemed to me to confirm this, and to indicate that it is coincident with the plan on which the Myriapoda have been created. M. Brandt (Recueil, p. 26) divides the Chilopoda into the *Schizotarsia* and *Holotarsia*. These appear to constitute natural sub-orders, and are consequently here retained as such.

There has been a great difference of opinion amongst naturalists as to the rank of the Myriapoda, and the position which they occupy amongst the articulata. Mr. Brandt, Gervais, Dana, and others consider them as nothing more than an order of the class Insecta; Le Conte (Class Coleop. N. Am. Introd., p. vii) considers them as a subclass of the class Insecta; whilst Leach, Latreille, Newport, T. Rymer Jones, &c., grant to them the rank of a class. The latter gentlemen differ, however, as to their position in the zoological plan. Mr. Newport places them just above the Vermes, and this seems to be their natural position.

There is doubtless a good deal of resemblance between a hexapod larva and a myriapod,

but the mode of development and growth of the latter is so different from that of the hexapoda, arachnida or octopoda, and crustacea or decapoda, that it seems to me they must be acknowledged as a separate class. Now, their method of development is similar to that of the Vermes, hence the reason of their being placed next above them. When a spider, or insect, or crustacean leaves the egg, its body has its maximum number of segments, and development takes place by the coalescence and disappearance of some of these. The embryonic myriapod, on the contrary, has its minimum number of segments, and develops by their increase. So that whilst the adult insect has generally fewer, never more segments than the young, the adult myriapod may have eight times as many, and never fewer than its young.*

Ord. I. CHILOPODA. *Leach.*†

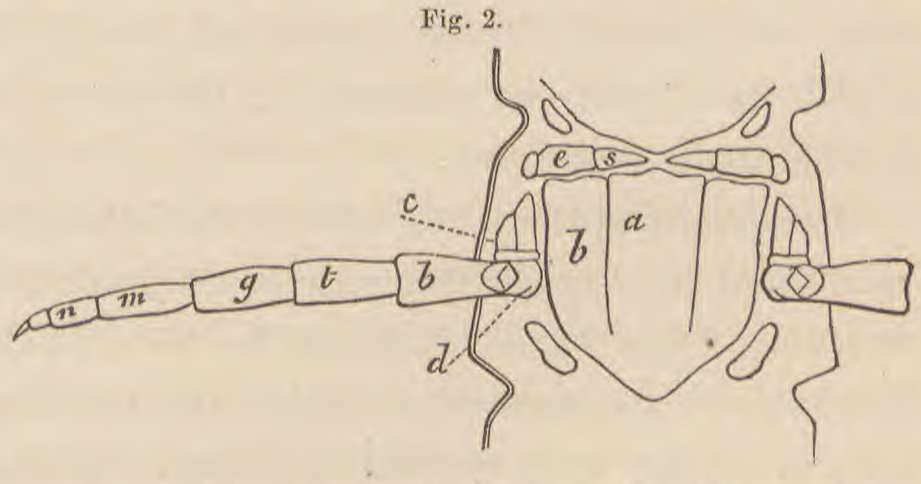
Corporis segmenta, singulum pedum pare unico instructum.

Segments of the body, each furnished with a single pair of feet.

The body in the Chilopoda is composed of segments, whose number varies from sixteen to several hundred. Each segment is furnished with a single pair of legs. There might seem to be an exception to this in the Cermatiidæ, but close examination shows that in them the fact of there being but one scutum to two segments is the cause of the apparent anomaly. In all the other families there is a scutum and sternum to each segment. These external bones, so to speak, are connected by a tough membrane, which forms the only protection to the sides. In the upper portions of this are placed the spiracles, in the lower the insertion of the legs.

Close to the spiracles, and belonging to the dorsal section, are two osseous points, the rudiments of the paraptera, which attain to some importance among the Hexapoda. At the insertion of the legs are several small plates, the epimera (Fig. 2, *c*), which afford points of origin to the retractor muscles of the legs. The posterior of the two embryonic subsegments forms the mass of the segment; but the scutum of the anterior is perhaps represented by a raised band on the front of the main scutum. The ventral portions of it are, however, much more distinct. These are

Fig. 2.



* I would refer any one desiring to follow this further to Mr. Newport's paper. Linn. Trans., vol. xix.

† Linn. Trans., vol. xi.

a series of small plates anterior to the sternum, representing the two parts of the primitive sternum (Fig. 2, *s*), and the two episterna (Fig. 2, *e*), as well as the epimeral plates.

The legs contain each a coxa (Fig. 2, *d*), a femur, *b*, a tibia, *t*, a tarsus, *g*, and metatarsal joints, *m*, *n*. The coxæ are generally small, except those of the posterior pair of legs, which are often very large, and are known as the lateral anal appendages. Among the Cermatiidæ and Lithobiidæ, however, they all attain to a considerable size. The metatarsal joints vary very much; in the genus Scolopendra there are but two to each leg, whilst among the Cermatiidæ there are a great number.

The head in the Chilopoda is composed of eight subsegments consolidated into two or more segments, as was first shown by Mr. Newport. The first segment is styled the cephalic. It reaches its maximum size in the Cermatiidæ, in which it is the most prominent part of the body, supporting a pair of very large compound eyes, and almost completely concealing the strikingly atrophied basilar segment. Traces of the division into the four subsegments, that existed during embryonic life, are occasionally met with, especially among the Lithobiidæ, but the embryological labors of Mr. Newport have shown conclusively that it is so formed. The head in the Scolopendridæ has, in addition to the cephalic segment, another one of variable size; this is the basilar. It is also found well developed in all the other families except the Cermatiidæ. Near its anterior border there is often found a deep crescentic groove; the portion separated by this from the main body, is called the prebasilar fold or subsegment. In the genus Mecistocephalus this subsegment is entirely separated from the rest, its scutum existing as a small plate immediately posterior to the cephalic, and is there called the prebasilar. In the other genera of the Geophilidæ this is wanting, but there exists posteriorly another segment, answering to the posterior portion of the basilar of the Scolopendridæ. It is the subbasilar of Newport. The under surface of the head, comprising as it does the organs of nutrition, is much more complicated than the upper, and, in order to show the relations of parts more clearly, I will trace them out minutely in the genus Scolopendra, where perhaps their analogy is most easily discovered.

On examining the under side of the head of a specimen of the genus Scolopendra, we will find a band constituting the most anterior portion, with which the antennæ partially articulate; this band I take to be the anchylosed primitive sterna and episterna of the first cephalic subsegment, of which the antennæ are the appendages. Just posterior and inferior to the eyes, we will see what is apparently an inversion of the cephalic scutum, but closer examination shows it to consist of two small plates, the superior exterior (Fig. 3, *e*), uniting with the scutum by suture, the inferior interior (Fig. 3, *h*) approximating to the other plate; the first of these is the atrophied episternum, the other the primitive sternum of the second cephalic subsegment. United with this sternum by

suture we will find posteriorly a larger plate (Fig. 3, *d*), which articulates on its inner side with another obliquely transverse plate (*b*), which also is conjoined on its inner side by another (*c*), and that too by another, and finally in the centre there is a small tooth, as it were. These plates are respectively the coxa, femur, tibia, tarsus, and the rudimentary metatarsæ (the central tooth) of the atrophied and misplaced appendages of the second cephalic subsegment. The tibia and tarsus are generally anchylosed together, but I have seen them separate. Conjoined and posterior to the coxa of the second cephalic subsegment we will find a large plate (*a*) articulating with the cephalic scutum by suture; this I take to be the primitive sternum and episternum of the third cephalic subsegment atrophied and fused together; to it the true maxillæ are articulated. These consist each of, first an elongated crooked plate (the coxa) articulating with two plates, the exterior of which (the femur) is armed with a tubercle, as in the mandibles, posterior legs, &c.; the inner plate is the tibia; these two plates articulate at their distal end with a third, the tarsus and metatarsus coalescent, but with the line of their junction very apparent. The maxillæ I believe to be the appendages of the third cephalic subsegment. Just anterior to the primitive sternum of the first, and posterior to that of the third, are often found some small plates which I believe to be epimeral. But the largest of the latter is probably the episternum of the fourth cephalic subsegment, which is scarcely to be found elsewhere. Proceeding still posteriorly we come to the maxillary palpi (Fig. 4), which are possessed each of a distinct femur (*f*), tibia (*x*), and tarso-metatarsal joint (*m*). They are the appendages of the fourth cephalic subsegment. Between them are two small plates, the lingua (Fig. 4, *l*), which I think are the primitive sterna, not episterna (as Mr. Newport believed), of the fourth cephalic subsegment. Posterior to the sterno-episternal plate of the third subsegment is a subtriangular plate, one of the episterna of the first basilar subsegment; interior to this is a large irregularly four-sided one, forming a portion of the palpus (Fig. 5, *a*); this is one of the primitive sterna of the first basilar subsegment; still within this is an elongated plate (*e*), the coxa of the palpus. With these two last the femur (*b*) of the palpus is articulated at its proximate end, while to its distal end is fitted the tibia (x), and to it the tarsus (*m*). The sterna and appendages of the second and third are very much coalesced and difficult to distinguish clearly; but I think that the dental lamina are probably the appendages of the second basilar subsegment, the

Fig. 3.

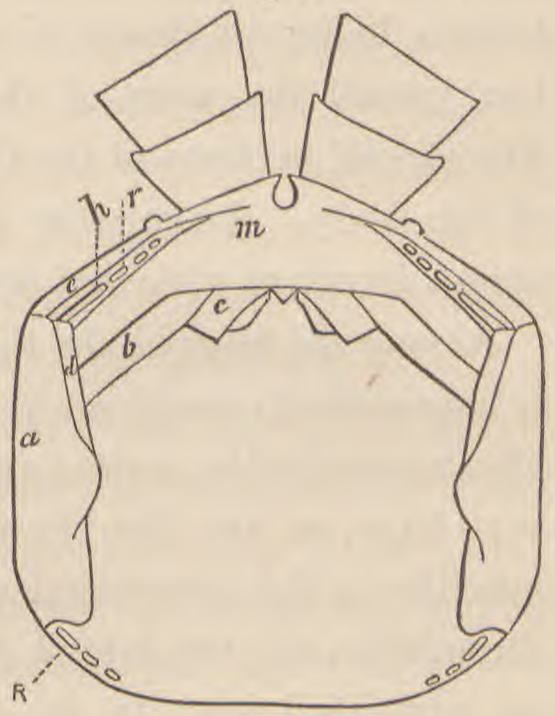


Fig. 4.



Fig. 5.



anterior portion of the labium, which I have frequently seen separated by a suture, being composed of the episterna and primitive sterna of the same subsegment. The mandibles are probably the appendages of the third basilar subsegment, the posterior portion of the labium being composed of the sterna of the same subsegment. Two plates, which are bent round the sides of the posterior portion of the labium, may be the episterna. The sternal portions of the fourth basilar subsegment are similar to those of the segments of the body. Among the Lithobiidæ the structure of the under portion of the head is almost identical with that described above.

Among the Geophilidæ the parts of the mouth are so consolidated and confused that it is impossible to recognize in the adult the original plan of construction and development. On examining the under surface of the head of a Mecistocephalus, we will find the labium very large, as are also the mandibles, while the maxillæ are apparently wanting, but the maxillary palpi are recognizable. Among the Cermatiidæ the labium is moderate, cleft in the middle, the two lateral halves being movable on one another, so as to form as it were an additional joint to the mandibles; which are otherwise enormously developed, especially as to length. The palpi are very long. The maxillæ and maxillary palpi are well developed.

Sub Ord. SCHIZOTARSIA.*

Antennæ longissimæ, setaceæ, cum tarsis multiarticulatæ. Oculi compositi.

Antennæ very long, setaceous, together with the tarsi multiarticulate. Eyes compound.

Fam. I. CERMATIIDÆ, *Leach.*

Scuta 8. Segmenta 16. Sterna 16. Scutorum stomata mediana. Pedes antennæque multiarticulatæ.

Scuta 8. Segments 16. Stomata of the scuta median. Feet and antenna multiarticulate.

In the Cermatiidæ the head is large, more or less truncate anteriorly, having its surface rough and uneven. The eyes are compound and very prominent. The palpi very elongate and spinous. The antennæ very long, and composed of a multitude of joints. The mandibles are elongate and distant. The scuta (eight in number) are rounded and deeply emarginate posteriorly, where they are furnished with a longitudinal, slit-like orifice or stoma. Their surface is more or less roughened with minute tubercles or spines. Their border is everted, and generally crenulate and spinous. The legs are very long, and serrated by parallel rows of spinulæ. They are also furnished with rings, of long slender

* Brandt, Recueil, p. 26.

spines, encircling the joints. The sides have nine pairs of spiracles, the openings into the tracheal vessels. The anal segment in the female is elongate, and the external organs of generation are furnished with a pair of forceps, replaced in the male by a pair of styliform appendages. The sterna are small; the last, the sixteenth, is merely rudimentary. It is very evident that the number of segments is sixteen, and that each scutum is formed by the coalition of two neighboring ones. The pattern of coloration is peculiar to this family; it consists of longitudinal stripes on the body and annuli on the appendages. There has as yet only one genus been found in this family, among which so great a uniformity exists as to make the distinguishing of species a task of considerable difficulty.

The color is probably a good specific character, but is seldom, if ever, preserved. I have seen specimens of *S. forceps* changed almost immediately to green or blue, or, more commonly, bright purple, by alcohol.

Any anatomical characters are very obscure; but Mr. Newport considers the proportionate lengths of the metatarsal joints as constant, and I have found them so, as far as my limited observations have gone.

The lengths of the antennæ and posterior pair of legs, as compared with the body, are also probably good characters, but very liable to misinterpretation; for it is difficult, often impossible, to tell when the former are broken and when the latter are imperfect, reproduced, appendages. Mr. Templeton, who first suggested these points, also makes use of the size of the marginal spines of the scuta in his descriptions. The peculiarities of the surface of the scuta also appear to be good secondary characters.

Gen. 1. CERMATIA, *Illiger.*

Caput magnum. Oculi prominentes. Stomata dorsalia latera incrassata.

Head large. Eyes prominent. Dorsal stomata with their sides thickened.

Scutigera, *Lamarck*, Anim. Sans. Vertb.
Selista, *Rafinesque*, Annals of Nature.

C. forceps.

C. viridi-brunnea, fasciis tribus longitudinalibus nigro-viridibus; capite antice breviter piloso, et linea depressa longitudinale mediana et ante oculos utrinque altera curvata, et altera tranversa inter oculos, et postice depressione lata insculpto; antennis mandibulisque ferrugineis: scutis spinulis numerosis asperatis, valde imbricatis, angulis rotundatis, marginibus elevatis sed tenuibus et "spinis quam in Cerm. coleoptrata evidentioribus;" lateribus plerumque rufescenti tinctis; femoribus singulo annulo unico saturate viridi; tibiis et tarsis biannulatis; pedum pari postremo in mare corpore vix ¼ longiore (in femina bis longiore); articulo metatarsali primo secundo fere quater longiore, sequentibus quinque conjunctis fere æquali; superficie ventrali flavescente; sternis mediis canaliculatis.

Greenish-brown, with three longitudinal stripes of deep green; head anteriorly shortly pilose, impressed with a median longitudinal line, and in front of the eyes a curved one on each side, and another transverse between the eyes; antennæ and mandibles ferruginous; scuta roughened with numerous spines, strongly imbricate, with the angles rounded, the margins elevated but thin, and the spines more pronounced than in C. coleoptrata; sides generally tinged with rufous; femora each with a single deep green ring; tibiæ and tarsi biannulate; last pair of feet in the male scarcely ¼ longer than the body (in female twice longer); first metatarsal joint nearly four times as long as the second, about equalling the five following conjoined; ventral surface yellowish; sterna medianly canaliculate.

SELISTA FORCEPS, *Rafinesque*, Annals of Nature, 1st No., 1820, p. 7.
CERM. COLEOPTRATA, *Say*, Journ. Acad. Nat. Sci., 1st series, ii.
" " *Lucas.*
" " var. FLORIDENSIS, *Newport*, Ann. and Mag. Nat. Hist. xiii, p. 95.
" FLORIDANA, *Newport*, Linn. Trans. xix, p. 353.
SCUTIGERA FLORIDANA, *Gerv.*, Apt. iv, p. 225, et Tabl. Myriap. (Exp. dans L'Amerique du Sud, part. Sept.)
CERMATIA FORCEPS, *Wood*, Journ. Acad. Nat. Sci., vol. v, new series, 1863, p. 12.

In specimens preserved for some time in alcohol, all traces of the original color are lost, the whole animal turning to a testaceous hue. The coloration of a very large fresh female before me is as follows:

The general tint is a very light olive-brown; the median stripe is black, continuous, strongly defined, and extending from between the eyes to the posterior border of the penultimate scutum, where it abruptly terminates. The lateral stripes are black, strongly defined, interrupted, and extending from the eyes to the posterior border of the last scutum. The interruptions are so arranged that most of the scuta present three blotches on each side. The anterior portion of the head has two stripes converging anteriorly to the median line. In front of these there is a sub-round marking prolonged anteriorly. Most of the femora are provided with a very incomplete greenish black annulus, which is, however, complete on the last pair. The tibia and tarsi are biannulated. The dorsal stomata are bordered with brilliant white.

Authorities differ as to the validity of this species. I have never seen *C. coleoptrata*, and therefore cannot offer an opinion.

Hab. United States, east of Rocky Mountains.

SUB ORD II. HOLOTARSIA.*

Tarsi 3 articulati. Antennæ vix elongatæ, 14-40 articulatæ. Oculi simplices, interdum multi, interdum nulli.

Tarsus 3 articulate. Antennæ scarcely elongate, 14-40 articulate. Eyes simple, sometimes numerous, sometimes wanting.

* Brandt, Receuil, p. 26.

Fam. II. LITHOBIIDÆ, *Newport.**

Scuta 15, inæqualia. Pedum posteriorum coxæ excavationibus in facie depressa. Antennæ elongatæ, setaceæ. Ocelli numerosi vel pauces.

Scuta 15, unequal. Coxa of the last pair of feet with impressions on a depressed surface. Antenna elongate, setaceous. Ocelli numerous or few.

The Lithobiidæ have the head large and well armed. The antennæ setaceous, elongate. The eyes stemmatous. In two of the genera, they are small and numerous, but in the third large and but two in number. The mandibular teeth are strong, very acute, and probably provided with a poison-gland at their base, although it has never been anatomically demonstrated in this family, that I am aware of. The scuta are of two kinds, a large one alternating with a small one. The females have the anal segment somewhat elongate inferiorly, and provided with a pair of forceps on each side. In the males these are replaced by a pair of minute styliform appendages. The posterior coxæ have a plain depressed surface with indentations, or, as I have called them, excavations on it. I have never seen a specimen of the type of the genus Lithobius; but Mr. Newport says, that in all his specimens of the family the larger depressed surface is a deep elongate oval, whilst the smaller excavations are transverse, oval, and furrow-like. There is, among the American species of the Lithobiidæ, a group in which the larger surface is scarcely depressed, with the smaller excavations round and almost punctiform. This I have indicated as a distinct genus, with the name of Bothropolys.

The specific characters of the Lithobiidæ are derived from the number of ocelli, the shape of the dental lamina with the number of teeth, the shape, color, and structure of the scuta, &c. The number of the eyes in the adult is fixed within certain limits for each species. But when the young Lithobiid emerges from the egg, it possesses but a single pair of eyes, besides wanting some of its segments. In the genus Henicops (not yet discovered in this country), the single pair of ocelli remain as a permanent character; but in the other genera the number of eyes are gradually increased until adult life. Mr. Newport seems to think the number of labial teeth a good specific character, but I have found it to vary considerably.

* Linn. Trans. xix, p. 275.

Gen. 1. LITHOBIUS, *Leach.*

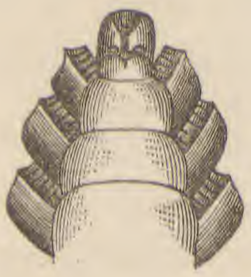
Antennæ multiarticulatæ. Caput latum, complanatum. Labium antice denticulatum, medium sulcatum, emarginatum. Coxarum excavationes magnæ, ovatæ, in serie unica in facie depressa dispositæ. (Fig. 6.)

Antenna multiarticulate. Head broad, complanate. Labium anteriorly denticulate, medianly sulcate, emarginate. Pits on the coxa large, ovate, arranged in a single series on a depressed face.

L. Americanus.

"L. ferrugineus; capite magno subquadrato margine postico elevato; antennis pubescentibus; ocellis nigris utrinque 25—26; labio complanato, polito, margine fere recto; denticulis 10, parvis, nigris, subapproximatis, scutis lævibus, convexis, subquadratis postice rectis; segmento præanali piloso, pedibus validis flavis spinis validis armatis."

Fig. 6.



Ferruginous; head large, subquadrate with the posterior margin elevated; antenna pubescent; ocelli black, on each side 25—26; labium complanate, smooth, its margin almost straight; denticules 10, small, black, subapproximate; scuta smooth, convex, subquadrate posteriorly straight; preanal segment pilose, feet robust, yellow, armed with strong spines.

L. americanus, *Newport*, Linn. Trans. xix, p. 305; Catalogue of British Museum (Myriapoda), p. 17.
" " *P. Gervais*, Apteres, iv, p. 236; et Tabl. des Myriap. (Exp. Amerique du Sud), p. 29.
? L. spinipes, *Say*, Journ. A. N. S., 1st series, vol. ii, p. 108; et in Œuvr. Entom. Ed. M. A. Gory, 1, p. 21.
? L. spinipes, *Lucas*, Hist. Nat. Anim., Art. iv, p. 543.
"L. multidentatus, *Newport*," *Wood*, Journ. Acad. Nat. Sci. 1863, p. 13.
"L. americanus, *Newport*," *Wood*, loc. cit. p. 14.

When I wrote my paper on the North American Chilopoda, I had not a large mass of material at my disposal, and fell into error in my identification of Mr. Newport's species. The characters which he relies on in separating his L. multidentatus and americanus vary so much in the two species that the extremes meet, and hence my mistake. The average number of ocelli is greater in B. multidentatus, but individuals occur of L. americanus with 33 ocelli, thus coming within the number assigned to multidentatus by Mr. Newport. The diagnosis of the species given above is that of Mr. Newport. The number of ocelli and labial teeth are too small. I would say, ocelli utrinque 26—33, denticulis 10—15. The head and scuta are distinctly but rather sparsely punctate. The alternate small scuta are proportionally very large. The scuta are quadrate or subquadrate. The posterior margins of the larger ones are straight, and the angles not prolonged, except in the last two or three, in which the posterior margin is somewhat crescentic. The angles of the lesser scuta are more prolonged than those of the others. The dorsal surface is not so

corrugated or wrinkled as in B. multidentatus; the plates give more of the appearance of thickness. Length 1¼ inches.

Hab. Eastern United States.

L. TRANSMARINUS.

Zähne der Unterlippe: 12. Zahl der Fühlerglieder: 38.
Zahl der Hüftlöcher: 5, 8, 7, 5 oder 6, 8, 7, 5.
Form der Hüftlöcher: oval. Körperlänge; 7½‴.
Sehr gewölbt, glänzend.

Kopf auffallend länger als breit, gewölbt, mit flacher Randeinfassung, die Kopffläche uneben mit vereinzelten, grob eingestochenen Punkten; hinter der sehr feinen Furchenlinie der Kopfspitze zwei runde Grülchen. Die Fühler lang, mit 38 Gliedern; Behaarung abgerieben (jedoch so viel sich noch erkennen lässt, ziemlich langborstig), das Endglied fast eiförmig.

Die Augen in fünf gebogenen Reihen, dicht gedrängt 7, 7, 5, 7, 5. Das Seitenauge oval, nahe an den übrigen. Die Unterlippe sehr glänzend, wenig gewölbt, der Zahnrand schmal, zu beiden Seiten der tiefen Mittelkerbe gebogen, beiderseits 6 kurze, stumpfe Zähne, wovon die äussern entfernter stehen. Die Unterlippe so wie die Lippentaster weitschichtig grob eingestochen punktirt. Die Rückenschilde gewölbt in den seiten etwas runzelig, der 4 Hauptschild mit einem Zahnfortsatze, dessen Innenrand aufgeworfen, auch die drei letzten Zwischenschilde mit Zahnfortsätzen, dessen Innenrand jedoch nicht aufgeworfen. Das 4., 5. und 6 Glieder Schleppbeine gleich lang, das 3. kurzer, alle Glieder seitlich zusammengedrückt, das 4—7. dicht fein eingestochen punktirt; am 3 und 4. drei Stacheln (ein mittler langer und zwei seitliche kürzere) am 5. nur der mittlere und der äussere; das 3 und 4. Glied unten mit einer Längsfurche an der Innenseite des 6 und 7. eine tiefe Längsrinne.

Die Hüftlöcher oval, am hintersten Beinpaar 5 oder 6, am vorletzten 8, am drittletzten 7, am vordersten 5. Am zweiten Gliede der weiblichen Genitalien die Zäpfchen lang und spitz; die Endkralle stumpf mit zwei ebenfalls stumpfen kurzen Seitenzähnchen.

Die Bauchschilde glänzend.

Bräunlichgelb, der Kopf, die Fühler, Unterlippe und Lippentaster röthlichbraun, letztere mit schwarzer Zangenspitze. Beine bräunlichgelb.

Vaterland. New Orleans.

Koch, Myriapoden Gattung Lithobius, p. 33.

L. MORDAX.

Zähne der Unterlippe: 12—14. Zahl der Fühlerglieder: ?
Zahl der Hüftlöcher: 6, 8, 8, 9. Form der Hüftlöcher: langlich.
Körperlänge: 14‴.

Mattglänzend, vorne ziemlich flach, hinten mehr gewölbt. Kopf breiter als lang, kahl, etwas uneben, mit schmaler Randeinfassung—überall, besonders aber die vordere Kopfhälfte sehr grob eingestochen punktirt.

Die Furchenlinie der Kopfspitze sehr fein, in der Mitte nicht eingedrückt. Fühler langgliederig, Glieder über 36. Unterlippe gewölbt, mit tiefer Mittelrinne, an der Basis sehr breit, weitschichtig grob eingestochen punktirt. Zahnrand mit tiefer Mittelkerbe, beiderseits derselben gebogen, mit 6—7 sehr langen und kräftigen Zähnen von denen die äussern weiter von einander entfernt, als die inneren; die Lippentaster grob eingestochen punktirt.

Augen in vier gebogenen Reihen 6,6,6,6,—das Seitenauge grösser, oval. Die vordern Rückenschilde wenig, die hintern mehr gewölbt, die Fläche besonders in den Seiten, uneben, rauh, mit zerstreuten grob eingestochenen Punkten, der vierte Hauptschild mit kurzer zahnartiger Verlängerung, deren Innenrand aufgeworfen, die drei hintern Zwischenschilde an den Hinterrandsecken mit sehr langen spitzen Zahnfortsätzen, deren Innenrand jedoch nicht aufgeworfen. Die Bauschilde in der Mitte mit einer rundlichen Impression. Die Schleppbeine sehr lang, das 4—7 Glied dicht fein eingestochen punktirt. Das 3 Glied das kürzeste, das 5. das längste, das 4 und 6 gleich lang, das 3 kurz und dick, das 4 stark aufgetrieben, mit tiefer, muldenartiger Längsvertiefung, dicker als das dritte, beide unten mit einer Längsfurche; die übrigen fast walzlich, seitlich nur wenig zusammengedrückt. Am 3 und 4. unten drei Stacheln (ein mittlerer langer und zwei seitliche kürzere) am 5 nur ein Stachel.

Hüftlöcher länglich 6, 8, 8, 9. Das ganze Thier oben rothbraun, ebenso die Fühler, Lippentaster, Unterlippe, die hintern Beine und letzten Bauchschilde; die Zangenspitze und Zähne der Unterlippe schwarzbraun. Die vordern Bauchschilde und Beine bräunlichgelb.

Vaterland. New Orleans."

Koch, Die Myriapoden Gattung Lithobius, p. 34.

I have never seen any Lithobii from the State of Louisiana, and therefore do not like to speak positively as to the validity of Herr Koch's species; still it seems certain that few if any of the characters which he gives are fixed and definite. The number of labial teeth, of the eyes, shades of color, &c., the examination of thousands—literally thousands—of specimens long since convinced me vary considerably,—at least in North American species. There appears to be only one character given by him which would indicate that L. transmarinus, Koch, is different from L. americanus, Newport; it is where he says: fourth chief scuta with a toothlike process, whose inner margin is reflexed (*aufgeworfen*). As to the number of the depressions on the posterior coxæ, they are not the same even on the two sides of the same individual. On page 39, Herr Koch gives the numbers in some five individuals. In these the one extreme is very nearly twice as great as the other. Are we, then, to create new species because of differences of 4 or 5 in the number of these depressions? Again: the only important difference between L. transmarinus and L. mordax, deducible from the description, is in the number of the ocelli. Herr Koch assigns only 24 to the latter; but Mr. Newport assigned 25—26 to L. americanus! Now, does it not seem very possible that L. transmarinus and mordax are one and the same species, which is really L. americanus of Newport?

L. PAUCIDENS.

L. ferrugineus; pedibus flavis; segmento-cephalico polito, postice margine elevato; antennis elongatis, pilosis: laminis dentalibus indistinctis, singula denticulis duobus valde sejunctis armata; ocellorum paribus 17; scutis alternis majoribus politis, vix asperatis, margine postico fere recto; scutis alternis minoribus margine postico recto et angulis externis productis; coxarum excavationibus parvis, vix ovatis.

Ferruginous; feet yellow; cephalic segment polished, with its posterior margin elevated; antenna elongate, pilose; dental lamina indistinct, each armed with two widely separated denticules; pairs of ocelli 17; alternate larger scuta polished, scarcely roughened, with their posterior margins almost straight; alternate minor scuta, with their posterior margins straight and their external angles produced; excavations on the coxa small, scarcely oval.

L. PAUCIDENS, *Wood*, Journ. Acad. Nat. Sci., new series, vol. v, 1863, p. 14.

The color of the only adult specimen that I have seen approaches an orange. The mandibles are rather large. The dental lamina are almost wanting, their margins somewhat rounded and armed with two acute widely separated teeth. The color of the three or four posterior sterna is darker than that of the rest of the body. The excavations of the posterior coxæ are small, few, and nearly round. The feet are yellowish, hairy, and with well-developed articular spines. Length 1 inch.

Hab. Fort Tejon, Cal.—J. Xantus de Vesey.—Smithsonian Collection.

L. PLANUS.

"L. ferrugineo-variegatus; capite magno subquadrato polito postice ad marginem elevato incrassato; antennis brevibus pubescentibus; ocellis utrinque 23; labio polito, pilis raris; laminis dentalibus lunatis angulis externis antice elongatis profunde emarginatis; denticulis 14 acutis, nigris; scutis dorsalibus complanatis rugosis marginis elevatis; pedibus nudis spinis articularibus parvis." Species mihi ignota.

Variegated with ferruginous; head large, subquadrate, polished, elevated, and thickened at its posterior margin; antennæ short, pubescent; ocelli on each side 23; labium polished, with scattered hairs; dental lamina lunate, anterior external angles elongate, profoundly emarginate; denticules 14 acute, black; dorsal scuta complanate rugose, their margins elevated; feet bare, with small articular spines. Species unknown to me.

L. PLANUS, *Newport*, Linn. Trans. xix, p. 366; Catalogue of British Museum (Myriapoda), p. 18.
" " *P. Gervais*, Apt. iv, p. 236; et Tabl. des Myriap. (Exp. Amer. du Sud, part. Sept.), p. 29.
" " *Wood*, Journ. Acad. Nat. Sci., new series, 1863, p. 14.

This species may belong in the genus Bothropolys, but, as I have never recognized it, I cannot say.

Gen. 2. BOTHROPOLYS, *Wood.**

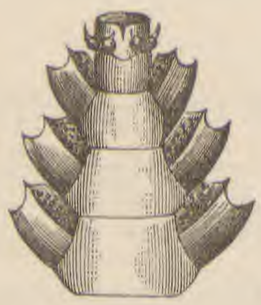
Ocelli numerosi. Coxarum excavationes, parvæ, fere rotundæ punctiformesque, in seriebus 3—4 dispositæ. (Fig. 7.)

Eyes numerous. Excavations on the coxa small, almost round and punctiform, arranged in three or four series.

B. MULTIDENTATUS.

B. brunneus; segmento cephalico postice margine elevato; antennis elongatis, sparse pilosis; articulis basalibus 4 longitudine fere æqualibus; laminis dentalibus distinctis, margine antico subrotundato, angulis anticis externis subproductis; denticulis 12—19; ocellis utrinque 32—37; scutorum anticorum marginibus et posticis et lateralibus elevatis sed scutorum posticorum lateralibus solum.

Fig. 7.



Brown; cephalic segment with its posterior margin elevated; antenna elongate, sparsely pilose; 4 basal joints about equal in length; dental lamina distinct, their anterior margin somewhat rounded, anterior external angle somewhat produced; denticules 12—19; ocelli on each side 32—37; both posterior and lateral margins of the anterior scuta elevated, of the posterior only the lateral.

L. MULTIDENTATUS, *Newport*, Linn. Trans. xix, p. 365; Catal. Brit. Mus. (Myriapoda), p. 17.
" " *P. Gervais*, Apteres, iv, p. 236; et Tabl. des Myriap. (Exp. dans L'Amerique du Sud, part. Sept.), p. 29.
B. NOBILIS, *Wood*, Journ. Acad. Nat. Sci., vol. v, new series, 1863, p. 15.

The alternate small scuta are frequently almost concealed by the larger ones. The surface of the scuta is wrinkled. The posterior angles of the larger scuta are very elongate. The labial teeth are large and acute, rarely coadnate. Length 1 inch.

Hab. Eastern United States.

B. XANTI.

B. brunneus, segmento cephalico polito, aurantiaco, margine postico elevato; antennis pilosis; ocellis utrinque 18; laminis dentalibus margine antico rotundato; denticulis 16—18, nigris, acutis; scutis valde asperatis, alternis majoribus postice valde emarginatis, alternis minoribus margine postico fere recto sed angulis posticis acutis et valde productis.

Brown; cephalic segment polished, orange, its posterior margin elevated; antenna pilose; eyes on each side 18; dental lamina with their anterior margin rounded; denticules 16—18, black, acute; scuta very much roughened, the alternate larger ones posteriorly strongly emarginate, the alternate smaller ones with their posterior margin almost straight, but the posterior angles acute and very much produced.

B. XANTI, *Wood*, Journ. Acad. Nat. Sci., new series, vol. v, 1863, p. 15.

* Journ. A. N. S., new series, vol. v, 1863, p. 15. *βοθρος*, fovea; *πολυς*, multus.

The head is rather large, with a curved suture running transversely from one set of ocelli to the other, which has its convexity directed posteriorly. The first scutum approximates the head in color, has its posterior margin strongly raised, and is only slightly roughened. The other large scuta are very rough, with (sometimes indistinct, but generally well marked) rugæ converging toward the median line anteriorly. The last scutum is, however, without rugæ, and but slightly roughened. It is much narrowed anteriorly and posteriorly, and somewhat elongate. The preanal sternum is almost circular, with two lateral curved impressions and a central shorter straight one, which are probably the remains of the sutures between the plates of which it was composed during embryonic life. The articular spines are rather strong. The smallest specimen has only twelve pairs of eyes. It affords me great pleasure to dedicate this species to Mr. Xantus, through whose "exhaustive collections" the rich fauna, of what was formerly a veritable *terra incognita*, has been so rapidly developed.

Hab. Fort Tejon, Cal.—J. Xantus de Vesey.—Smithsonian Collection.

B. BIPUNCTATUS.

B. brunneus; segmento cephalico polito, margine postico elevato, labioque et sparse profunde et dense minute punctatis; ocellis utrinque 18; antennis punctatis, sparse pilosis; laminis dentalibus brevibus, latis, denticulis nigris acutis 18 armatis, margine subrotundato; scutis alternis majoribus capite simillime punctatis, politis, vix asperatis, postice emarginatis; scutis alternis minoribus postice margine recto et angulis haud productis; sternis politis; pedibus punctatis, subrobustis.

Brown; cephalic segment polished, with its posterior margin elevated, together with the labium both sparsely profoundly and densely minutely punctate; ocelli on each side 18; antenna punctate, sparsely pilose; dental lamina short, broad, armed with 18 acute black denticules, margin somewhat rounded; alternate larger scuta punctate similarly to the head, polished, scarcely roughened, posteriorly emarginate; alternate lesser scuta with their posterior margins straight, and their angles not produced; sterna polished; feet punctate, rather robust.

B. BIPUNCTATUS, *Wood*, Journ. Acad. Nat. Sci., vol. v, new series, 1863, p. 16.

The head is of moderate size, with the posterior margin slightly emarginate and not elevated in the centre. The larger scuta are not deeply emarginate, but somewhat roughened, with a suture on each side; the anterior portion of which is longitudinal, but the posterior transverse. The transverse suture, running from one set of eyes to the other, is not as well marked as in B. Xanti. The posterior scutum is rather deeply emarginate behind. The preanal sternum is not as circular as in B. Xanti, but has similar markings.

The appearance which I have described as *densely minutely punctate* is seen only under a very high magnifying power, and is common in a greater or less degree to most species. Length 1 inch.

Hab. United States, west of Rocky Mountains.—Dr. Geo. Suckley, U. S. A.—Smithsonian Collection.

Fam. IV. SCOLOPENDRIDÆ, *Leach.**

Segmenta podophora 21—23. Oculi pauces vel nulli. Pedes postremi incrassati, plerumque spinosi.

Feet-bearing segments 21—23. Ocelli few or none. Last pair of feet thickened and generally spinous.

In this family the principal generic characters are founded upon the number of the segments of the body, the shape of the head, the number and form of the spiracles, the absence or presence of eyes, and the form of the terminal segment and its appendages. In some cases the number of joints of the antennæ seems to be a constant generic subcharacter. In the large genus Scolopendra—the Titans of the Myriapoda—the principal specific characters are founded upon, first, the number of segments to the antennæ; secondly, the number and arrangement of the labial teeth; thirdly, the peculiarities of the posterior feet; fourthly, the shape and comparative size of the head. I have no doubt that the number of joints to the antennæ is fixed for most species, but it serves more generally to distinguish groups than single species; yet it occasionally is the most reliable character separating closely allied forms. Unfortunately it must be used with great caution in the identification of individuals; for, owing to the ease with which portions of the antennæ are lost, the want of a certain number is a very indefinite negative character. After detaching a few of the distal joints, no trace of their former presence is left. For the same reason much caution is also necessary in assigning the number in a description. M. Saussure has found so much variation in this character that he considers it worthless. It is possible that it may vary in certain species; but the differences generally consist in there being too few joints, which, as has been just stated, is to be looked for, and reproduced antennæ probably have occasionally an abnormally great number of very small articles. The number and arrangement of the labial teeth sometimes constitute a good character, but there is often an agreement between distinct forms, and on examining large suites of individuals, I have found more variance in the same species than reading would lead one to look for. The posterior legs furnish the best criteria in the distinguishing of species. Most species have peculiarities either in the shape or relative size of the joints, or in the number or arrangement of spines on them. In order to show the amount of constancy that these characters possess, I have drawn up a series of tables, which may aid in establishing their value. The color, I think, is not to be depended upon, although Mr. Newport seems to attach much importance to it. In the preservation of specimens it is very liable to be altered or destroyed; besides this fact, my studies of these animals, both in museums and, to a limited extent, in the Tropics, lead me to the opinion that the color

* Linn. Trans. xi.

varies exceedingly, even during life. Size is often a good distinguishing character of a species, although scarcely available for the identification of an individual.

If we consider a species as the expression of a preconceived idea, there must be, as it were, a type of every species around which the individuals cluster, restrained from departing beyond a certain limit from the central nucleus. We can see then how there may be species perfectly distinct, but the individuals of which may so approximate that there may be difficulty in placing some of them. Does the mere difficulty or impossibility of placing an individual necessarily invalidate the claims of the species? The moss *Leucobryum glaucum*, Hampe, is acknowledged by all botanists (I believe) as distinct from *L. minus*, Hampe, the most tangible difference being that the former fruits in October, the latter in May. Now I have found fruiting specimens in April, which are undoubtedly referable to *L. glaucum;* but had they been found a month or two later, would any botanist have hesitated in labelling them *L. minus?* Indeed, one of the best American authorities told me, that had I so found the specimen, he would have pronounced it to be *L. minus*, as it would not have been possible to have known that the capsules were those of the previous year.

In the other genera of the Scolopendridæ the specific characters are pretty much the same as in the true Scolopendra. But some characters specific in the latter, elsewhere become generic subcharacters.

Subfam. I. SCOLOPENDRINÆ, *Newport.**

"Spiracula valvularia in paribus 9."

Spiracles valvular in 9 pairs.

Gen. 1. SCOLOPENDRA, *Linn.*

Segmentum cephalicum imbricatum. Oculi stemmatosi, utrinque 4. Antennæ attenuatæ. Pedum paria 21.

Cephalic segment imbricate. Ocelli stemmatous, 4 on each side. Antennæ attenuate. Pairs of feet 21.

S. HEROS.

S. testacea; segmento cephalico subovato, minute punctato; antennis 25 articulatis; dente mandibulari producto, gracile; dentibus labialibus 8—10, duobus intimis utrinque plerumque coadunatis; pedibus plerumque luteolis; paris postremi articulo basali, intus 5—7 spinis,† subtus 7—10 spinis in serie triplici dispositis, processu angulari 3—10 spinis; appendicibus analibus lateralibus elongatis, minute profunde punctatis, spinis apicalibus utrinque 5—7 et altera marginale armatis.

* Linn. Trans., vol. xix, p. 377.

† When giving the spines on the inner edge of a leg, I do not (as some do) include those on the terminal angular process; these are afterwards given separately.

Testaceous; cephalic segment subovate, minutely punctate; antennæ 25 articulate; mandibular teeth produced, slender; labial teeth 8—10, the inmost two on each side generally coadnate; feet generally yellowish; basal joint of the last pair within with 5—7 spines, beneath 7—10 arranged in a threefold series, angular process with 3—10 spines; lateral anal appendages elongate, minutely profoundly punctate, with 5—7 apical, and a marginal spine on each.

S. HEROS, *Girard*, Marcy's Report of Explorations on the Red River, p. 272, pl. xviii.
" " *Wood*, Journ. A. N. S., new series, vol. v, 1863, p. 18.

Var. CASTANEICEPS.

S. viridis; capite antennisque rubro-castaneis; pedibus plerumque luteolis, interdum viridibus; paris postremi articulis basalibus saturate viridibus.

Green; head and antennæ reddish chestnut; feet generally yellowish, sometimes green; basal joints of last pair very deep green.

S. CASTANEICEPS, *Wood*, Proc. A. N. S., 1861, p. 11; Journ. A. N. S., new series, 1863, vol. v, p. 18.

The prebasilar fold is connate with the basilar segment, the suture is generally, however, well marked, existing as a deep groove. The cephalic segment is slightly emarginate between the antennæ. The labial teeth vary from 8—10 in number; there will sometimes be four on one side and five on the other, the external tooth apparently being the missing one. The antennæ are 25-jointed. Out of nearly a hundred specimens that I have examined, only two or three had one or two supernumerary joints developed. The scuta are polished, generally minutely and sparsely punctate, often obscurely bicarinate, the posterior with their lateral margins elevated. The last pair of legs are rather robust, with the basal joint longer than the tibial. The scuto-episcutal sutures are apparent, the sterno-episternal very well marked. Length 5½ inches.

Hab. Georgia, Alabama, Louisiana, Texas, New Mexico, &c.

TABLE SHOWING THE VARIATIONS IN SOME OF THE MORE IMPORTANT SPECIFIC CHARACTERS.

Number of specimen.*	Labial teeth.	Spines on inner side of basilar joint of last pair of legs.	Spines on under surface of basilar surface of last pair of legs.	Spines on terminal angular process.	Spines on anal appendages.	
					Apical.	Marginal.
319	4	6	2 3 3	8	5	1
	4	6	2 3 3	6	7	1
	4	8	3 3 3	7	6	0
	4	8	2 3 3	6	6	1
197	5	leg wanting.			6	?
	4	4	3 4 2	11	5	1
322	4	6	2 3 3	6	6	0
	4	6	2 2 2	6	5	0
	4	6	2 4 2	7	6	1
	5	5	2 4 3	7	6	1
	5	6	2 4 3	7	6	1
	5	6	2 2	7		
	5	5	3 4 3	6	6	1
	5	7	3 4 3	6	5	1
		6	1 3 3	6	6	1
		6	2 3 2	6	6	1
36	3	6	3 4 3	7	7	1
	4	6	3 4 3	7	5	0
	5	7	2 4 3	6	5	1
	4	5	2 3 3	6	5	1
180	4	6	3 3 3	7	6	1
	4	6	2 4 3	7	7	0
	4	6	2 3 3	5	6	2
	4	6	2 3 3	4	6	3
	4	7	1 2 3	11	8	1
	4	7	2 3 2	7	7	1
101	4	6	2 3 3	6	5	1
	4	a reproduced leg.			5	1
†313	4	5	3 2 2	2	4	0
	4	a reproduced leg.			3	0
	4	‡4	6	about 30	8	1
	4	5	2	about 25	9	1
	4	6	2 3 3	6	8	?
	3	6	2 4 3	7	8	1
	4	6	2 4 3	8	8	1
	4	7	2 4 3	7	8	1
107	5	8	3 4 3	6	9	1
	4	a reproduced leg.			7	1
	5	?	? ? ?	?	8	1
	4	9	2 3 2	9	8	1
	§	?	? ? ?	?	8	1
		6	2 3 3	7	8	1
	4	?	? ? ?	?	9	1
	4	7	2 4 3	8	9	1
113	5	6	3 4 3	4	7	1
	4	?	? ? ?	?	7	1
	4	4	2 2 1	6	?	?
	4	?	? ? ?	?	6	

Number of specimen.	Labial teeth.	Spines on inner side of basilar joint of last pair of legs.	Spines on under surface of basilar surface of last pair of legs.	Spines on terminal angular process.	Spines on anal appendages.	
					Apical.	Marginal.
	6	0	2 6 3	8	9	1
	4	9	3 5 3	6	8	2
	3	7	3 4 3	8	7	1
	3	7	2 4 3	7	8	0
	4	8	2 4 3	8	9	1
	4	9	3 4 3	7	8	1
	4	6	3 4 3	6	7	0
98	4	7	2 3 3	6	10	1
	4	9	3 4 3	3	6	1
	4	8	3 4 4	3	5	1
	4	7	2 4 4	8	7	1
	4	8	2 4 4	6	0	1
	4	6	2 4 3	8	8	1
	4	7	3 4 3	6	8	1
	5	5	3 3 3	5	8	1
	4	?	? ? ?	?	8	1
233	4	8	2 4 3	6	7	1
	5	7	2 4 3		8	1
170	4	8	2 4 2		8	1
	4	7	2 3 3		8	1
150	4	5	2 5 3	6	7	1
	4	5	2 5 3	8	7	1
Type of Castaneiceps.	5	5	2 4 3	5	5	0
	4	5	2 4 3	5	7	1
30	5	6	3 3 3	6	6	1
	5	6	2 4 3	5	8	1
62	4	7	3 3 3	6	5	0
	4	6	3 3 3	5	5	1
38	4	6	3 4 3	7	6	2
	4	7	3 3 4	8	6	1
130	4	leg wanting.			4	1
	4	6	4 1 4 2	4	5	1
	4	6	2 4 3	6	6	1
	4	6	2 4 3	6	8	1
290	4	6	2 4 3	9	5	1
	4	7	2 4 3	8	5	2
	5	7	2 3 1	7	8	1
	4	7	2 4 3	0	6	1
94	4	a reproduced leg.			6	1
	4	6	3 3 3	6	5	1
	4	12	‖3 3 3	7	5	0
	4	11	4 3 2 2	8	6	1
201	4	6	2 4 3	6	6	1
	4	5	2 2 3	7	7	1
	5	6	2 4 3	8	7	1
	5	7	2 3 4	4	6	1

* The numbers in this column refer to the Smithsonian Collection.
† This is probably a very young individual of this species.
‡ The last legs of this specimen are evidently a reproduced pair.
§ Apparently a reproduced pair of dental lamina, as the teeth are not developed.
‖ The spines on this individual are smaller than common. It is a curious variation.

S. POLYMORPHA.

S. olivaceo-brunnea; capite dilute castaneo; segmento cephalico subovato, postice subtruncato, fere impunctato; antennis 30 articulatis; dente mandibulari tuberculo basali magno; dentibus labialibus 8, maximis, duobus intimis utrinque coadunatis, externis sejunctis; scutis interdum margine posteriore nigro-viride, marginibus lateralibus plerumque liberis; pedibus postremis robustis, supra subcomplanatis; articulo basali subdepresso, intus 3—7 spinis, subtus 10—18 spinis in serie quadruplici (interdum inordinatim) dispositis, processu angulari aut bifido aut trifido aut quadrifido; appendicibus analibus lateralibus singula 4—8 spinis apicalibus et altera marginali.

Olive-brown; head light chestnut; cephalic segment subovate, posteriorly subtruncate, almost impunctate; antennæ 30 articulate; mandibular tooth with a large basal tubercle; labial teeth 8, very large, the inmost two on each side coadnate, the external distant; scuta sometimes with the posterior margin blackish-green, the lateral margin generally free; last pair of feet robust, above subcomplanate; basal joint, and median also, subdepressed, within with 3—7 spines, below with 10—18 spines arranged in a fourfold series (sometimes irregular), angular process either bifid, trifid, or quadrifid; lateral anal appendages, each with 4—8 apical spines and a marginal one.

S. POLYMORPHA, *Wood*, Proc. Acad. Nat. Sci., 1861, p. 11. Journ. A. N. S., new series, 1863, p. 20.

The prebasilar fold is apparent but connate with the rather large basilar segment. The first segment of the body is very small; the scuto-episcutal suture are barely traceable, but the sterno-episternal are much more distinct. In a few individuals the labial teeth are small and coadnate. The color shades off from that given above to a testaceous chestnut. This species is closely allied to *S. heros*, and perhaps a differential diagnosis would not be amiss. The most important difference is in the number of joints to the antennæ. Owing to the ease with which these animals lose portions of these organs, the want of the typical number is not to be relied on in the identification of individuals. Another character which also is often not available for individual identification, but which characterizes this species, is the small size attained to. The spines of the lower surface, of basal articulations of last pair of legs, are more numerous than in *S. heros*, and arranged in four rows instead of three. The difference in arrangement is, perhaps, more apparent than real; the homologue of the first row of spines existing in some specimens of *S. heros*, but being placed a little higher up, they are thrown with those on the inner side of the limb. The angular process has fewer spines than in *S. heros*. Finally, although the species do exist on common ground, yet *heros* is a more tropical and *polymorpha* a more boreal animal, the regions which they occupy merely overlapping somewhat. Length $3\frac{1}{2}$ inches.

TABLE SHOWING THE VARIATIONS IN SOME OF THE MORE IMPORTANT SPECIFIC CHARACTERS.

Number of specimens.	Labial teeth.	Spines on inner side of basal joint of last pair of legs.	Spines on lower surface of basal joint of last pair of legs.	Spines on internal angular process.	Spines on lateral anal appendages.	
					Apical.	Marginal.
Type spec. in Coll. of A. N. S.	4	4	2 2 4 1 4*	3	8	1
	4	5	2 3 1 4 3	3	7	1
	4	5	1 3 3 3	2	6	0
	4	5	2 3 3	2	6	0
	4	6	2 3 5 1 3	3	5	1
	4	5	3 3 4 3	4	8	1
	4	6	2 1 2 4 1	4	6	0
	3	5	2 1 2 3 3	4	3	2
	5	5	2 3 3 2	4	8	1
	4	4	2 3 3 2	5	7	1
	4	5	2 3 4 1 2	5	5	0
	4	5	2 3 5 1 3	4	6	2
	3	5	3 2 4 3	4	6	0
	2	5	2 3 3 1 3	4	5	1
210	4	5	2 1 3 5 3	3	7	1
	4	5	2 4 5 3	3	5	1
†337	5	11	2 3 4 3 2	3	0	1
	4	?	? ? ?	?	0	1
242	4	1	2 2 1	4	7	1
	4	3	4 3 4 3	3	7	1
135	4	6	2 2 4 3	4	6	1
	4	5	2 3 5 5	4	4	1
	4	6	2 4 2 4 4	4	7	1
	4	5	1 3 5 4 4	4	6	1
334	4	7	3 2 3 2 1	4	6	1
	4	5	4 3 4 3	4	5	1
338	4	4	2 3 4 3 1	4	6	1
	4	3	2 1 3 3 1	3	6	1
	4	3	2 3 4 3	4	5	2
	4	5	2 3 3 3	3	6	0
	4	4	2 3 4 3	3	7	1
	4	5	3 3 4 3	4	7	0
	4	5	3 3 4 3	4	6	0
	A rep lam.	5	3 3 5 3	5	6	1
	4	5	4 2 5 4	3	7	1
	4	5	4 3 5 1 4	5	7	1
	4	7	2 2 2 4 2	6	6	1
	4	6	4 2 2 4 3	4	6	1
	4	6	2 4 4 4	4	7	1
	4	?	? ? ? ?	?	7	1
339	4	5	3 2 4 4 4	5	6	1
	4	5	3 5 5 3	4	5	1
	4	6	3 1 5 4 4	4	6	1
	4	5	3 4 5 4	4	6	1
227	4	6	3 3 5 4	4	7	1
	4	7	2 3 1 4 3	2	8	1
	4	5	3 3 5 4	4	8	1
	4	10	3 4 3 3	6	7	1
	4	5	3 2 3 4 3	2	6	1
	4	5	5 3 5 3	2	8	1
	4	7	3 3 5 5	4	8	0
	4	4	3 4 4 4	4	7	0

Hab. Sonora, Kansas, N. Texas.

S. VIRIDIS.

S. viridi-brunnea; segmento cephalico late ovato, sparse leviter punctato; pedibus flavis; antennis 23 articulatis, plerumque haud pubescentibus; dentibus labialibus 8, duobus intimis utrinque arcte coadunatis, externo acuto, sejuncto; laminis dentalibus elongatis; pedibus prostremis subcylindricis, modice robustis; articulo basali tibiali longiore, supra subconvexo, margine haud elevato, intus 2—5 spinis, subtus 7—12 spinis in serie vel triplici vel quadruplici dispositis, processu angulari 1—2 spinis; appendicibus analibus lateralibus profunde denseque punctatis, interdum elongatis, singula spinis apicalibus 2—5, et interdum altera marginale armata.

Greenish-brown; cephalic segment broadly ovate, sparsely lightly punctate; feet yellow; antenna 23 articulate, generally not pubescent; labial teeth 8, the inmost two on each side closely coadnate, the external acute, distant; dental lamina elongate; last pair of feet subcylindrical, rather robust; basal joint longer than the tibial, above convex, its margin not elevate, within 2—5 spines, below 7—12 spines arranged in a threefold or fourfold series, angular process 1—2 spines; lateral anal appendages profoundly densely punctate, sometimes elongate, each armed with 2—5 apical spines, and sometimes another marginal.

* The typical number of rows is four. The variations from this are caused by some of the spines being a fraction of a line from their normal position; they generally may be placed in four crooked rows.

† Are the hind legs with the anal appendages the original ones, or are they reproduced?

S. VIRIDIS, *Say*, Proc. A. N. S. 1821, p. 110; Œuvr. Entom. Ed. Lequien t. i, p. 23.

S. PUNCTIVENTRIS, *Newport*, Ann. and Mag. Nat. Hist. xiii, p. 100; Linn. Trans. xix, p. 386; Catal. Brit. Mus. Myriap., p. 33.

S. PUNCTIVENTRIS, *P. Gervais*, Apteres t. iv, p. 277.

S. VIRIDIS, *P. Gervais*, Apteres t. iv, p. 277; et Tabl. des Myriap. (Exp. Amer. du Sud, part. sept.), p. 30.

" " *Wood*, Journ. A. N. S., new series, vol. v, 1863, p. 22.

S. PARVA, *Wood*, Proc. A. N. S., 1861, p. 10.

The antennæ are generally, but not invariably, without pubescence. The first segment of the body is the smallest, the third the next. The sutures between the true sterna and episterna are well marked, those between the scuta and episcuta barely traceable. The cephalic segment is slightly depressed. The dental lamina have their margins rounded in some specimens. The scuta are frequently bordered with very dark green posteriorly. The dorsum in some individuals has a dark central stripe, vanishing posteriorly. This is, without doubt, the species intended to be indicated by Mr. Say, although his description is exceedingly indefinite and scarcely agreeing with the facts. I have, however, seen one specimen with its posterior feet tipped with blue, and another in which the posterior margination was yellowish, as he describes them. Neither have I any doubt in referring Mr. Newport's *S. punctiventris* to this species, although the number and arrangement of the spines on the posterior feet differ somewhat from those given by that author. One specimen belonging to the Smithsonian (No. 329) approximates to his description. The types of *S. parva* are in the collection of the Academy of Natural Sciences, brought from the mountains of Georgia by Dr. Le Conte. Length 2 inches.

TABLE SHOWING VARIATIONS IN SPECIFIC CHARACTERS.

Number of specimen.	Labial teeth.	Spines on inner surface of basal joint of posterior pair of legs.	Spines of inferior surface of basal joint of posterior pair of legs.	Spines on terminal angular process.	Spines on lateral anal appendages.	
					Marginal.	Apical.
116	4	5	2 2 2 2	2	3	
	4	6	2 3 2	2	3	
	4	4	2 1 2 2	2	4	1
	4	?	? ? ?	?	5	1
	?	5	2 2 3 2	2	3	0
	4	4	2 1 2 2	2	3	1
336	4	5	3 2 4 3	2	3	1
	4.	5	3 2 3 3	2	5	1
332	4	?	? ? ? ?	?	3	0
	4	5	2 3 3 2	2	3	0
	5*	5	2 2 2 3 2	2	3	1
	7		a reproduced leg.		4	1
170	4	5	3 2 2 2	2	3	1
	4		a reproduced leg.		5	1
329	4	5	2 2 2	1	3	0
	4	?	? ? ?		2	0

Hab. Florida, Georgia.—Smithsonian Collection.

* The labial teeth in this specimen are very small and much coadnate.

S. MORSITANS.

S. flavescens; scutis plerumque postice viridi marginatis; segmento cephalico postice subtruncato, basali magno; antennis 20 articulatis; laminis dentalibus, margine antico leviter rotundato; dentibus 8—10, brevibus, obtusis; pedibus compressis; pedibus postremis brevibus, robustis, supra complanatis, subtus valde convexis; articulis basali et tibiali marginibus superioribus elevatis et fere rectangulis; articulo basali intus 5 spinis, subtus spinis 7—9 triseriatis alternantibus; processu angulari valde elongato, spinis 3—5; appendicibus analibus lateralibus dense punctatis, apice breve, spinis 3—4; squama preanali longitudine latiore.

Yellowish; scuta generally margined with green; cephalic segment posteriorly subtruncate, basal large; antennæ 20 articulate; dental laminæ, with their anterior margin slightly rounded; teeth 8—10, short, obtuse; feet compressed, last pair short, robust, above complanate, below very convex; basal and tibial joints with their superior margins elevate and almost rectangular; basal joint within 5 spines, below 7—9 spines in three alternating series; angular process very much elongated, spines 3—5; lateral anal appendages densely punctate, their apex short, with 3—4 spines; preanal scale broader than long.

SCOL. MORSITANS, *Linn.*, Syst. Nat. i, p. 1063.
" " *Newp.*, Linn. Trans. xix, p. 378.
" " *Wood*, Journ. A. N. S., 1863, p. 23.
SCOL. MARGINATA, *Say*, in Journ. Acad. Nat. Sci. Philad., 1821, p. 9; et in Œuvr. Entom. Ed. Gory. livr. i, p. 22.
SCOL. BRANDTIANA, *Gervais*, in Ann. Sc. Nat., Janv. 1837, p. 50; et Apt. iv, p. 280.
SCOL. PLATYPUS, *Brandt*, Recueil, p. 61.
" " *Newport*, in Ann. and Mag. Nat. Hist. xiii, p. 98.
S. OTOMITA, *Saussure*, Mem. Soc. Phys. de Genev., 1860, xv, p. 383, f. 42.

"This species closely resembles *S. cingulata* in its general appearance. The spinules on the inferior surface of the posterior legs are arranged in three series which alternate with one another, so that, as remarked by Mr. Brandt, who first correctly described this species, they form with each other a succession of triangles. The preanal scale is very short, somewhat quadrate, with the posterior margin very slightly rounded. The lateral appendages also are short, with a slightly produced bifid apex."

Notwithstanding the labor devoted by different naturalists to this species, I think it possible that it will be hereafter found that its history as now accepted is incorrect. The geographical range, as given by Mr. Newport, extends over those portions of South, Central, and North America which lie in or near the tropics, as well as over the whole of the West Indies and an unknown extent of China. Verily, it must be the cosmopolite of the Scolopendridæ. I have seen an individual from Japan which I believe to be the var. β of Newport. It very closely resembles the North American specimens, but a suite may show that it is distinct. I have quite a number of Scolopendræ from Georgia and East Florida, but there is not a specimen of *S. morsitans* amongst them. I suspect that *S. marginata* and *S. viridis* of Say are identical species, and that *S. morsitans* is not an inhabitant of the

United States. Say's descriptions are absolutely no guides to the species intended. M. Gervais adopts Say's species as good, and gives the following synonymy:*

"S. MARGINATA, *Say*, Journ. Acad. Nat. Sci., t. ii; p. 100, &c.
S. MORSITANS, partim, *Newp.*, Trans. Linn. Soc. London, t. xix, p. 379."

Length 4 inches.

Hab. Florida?

S. INÆQUIDENS.

S. viridi-brunnea; segmento-cephalico punctato, parvo, basali magno postice subtruncato; antennis interdum viridibus, pubescentibus, 17 articulatis; labio mandibulisque sparse subprofunde punctatis; laminis dentalibus elongatis; dentibus 6—8, utrinque intimis duobus arcte coadunatis, duobus externis sejunctis, acutis; scutis interdum postice saturate viridi aut cæruleo marginatis; pedibus luteolis, gracilibus, longis; postremis robustis, articulo basali supra subconvexo, intus 3—8, subtus 7—10 spinis; processu angulari 2—6 spinis; appendicibus analibus lateralibus dense profunde punctatis, elongatis, spinis apicalibus 3—5.

Greenish-brown; cephalic segment punctate, small, basal large posteriorly subtruncate; antennæ sometimes green, pubescent, 17 articulate; labium and mandibles sparsely subprofoundly punctate; dental laminæ elongate; teeth 6—8, on each side, the two inner closely coadnate, two external distant, acute; scuta sometimes margined posteriorly with deep green or blue; feet yellowish, slender, long, the last pair robust, with the basal joint above subconvex, within 3—8, beneath 7—10 spines; angular process 2—6 spines; lateral anal appendages densely profoundly punctate, elongate, with 3—5 apical spines.

S. INÆQUIDENS, *Gervais*, Suit. a Buffon, Aptéres, vol. iv, p. 277; Exp. Amer. Sud. (Castelneau) Myriap., p. 30.
" " *Wood*, Journ. A. N. S., new series, 1863, vol. v, p. 25.

The cephalic segment is small, truncate posteriorly, and has its sides remarkably straight. The basal segment is very large, fully half again as broad as the cephalic. The antennæ are sometimes green or blue, and in all of our specimens pubescent on their distal portion. Their joints are short and almost globose. The scuto-episcutal sutures are well marked, but not so strongly as the sterno-episternal. The legs are slightly compressed. The basal joint has all of its margins well defined, so that it is scarcely subcylindrical, but rather subparallelopipedal. The spines are arranged in rows on elevated bases, so as to give the appearance of being on an interrupted crest or raised line. The apices of the lateral anal appendages are much prolonged, slightly curved upwards, impunctate and almost diaphanous. This species is separated from its southern representative, by the more rectangular and smaller cephalic segment and the larger basilar, by the more moniliform and fewer jointed antennæ, as well as by the differences in the structure of the lateral teeth and posterior pair of feet. I was at first disposed to consider the specimens as representing a species distinct from that of M. Gervais, but further examination has con-

* See Aptéres, t. iv, p. 276; et Tabl. des Myriap. Americ. (Exp. Amer. Sud. sept. part.) p. 30.

vinced me that that naturalist had a specimen with reproduced hind feet; yet it is worth while to append his description, so that the correctness or incorrectness of this opinion may be more easily shown.* Length 2½ inches.

TABLE SHOWING VARIATIONS IN SPECIFIC CHARACTERS.

Number of specimen.	Labial teeth.	Spines on inner surface of basal articulation of posterior pair of legs.	Spines on lower surface of basal articulation of posterior pair of legs.	Spines on terminal angular process.	Spines on lateral anal appendages.
267	3	3	10	2	3
	a reprod. lam.	5	8	2	3
	4	5	8	1	3
	4	4	8	2	3
268	4	5	7	2	4
	4	?	?	?	5
	4	5	7	6	4
	4	8	9	6	4

Hab. Illinois.—R. Kennicott.—Smithsonian Collection.—Massachusetts Museum Comparative Zoology.

S. LONGIPES.

S. castanea, robusta; capite castaneo, magno; segmento cephalico ovato, sparse minute punctato: segmento basali maximo; antennis 17 articulatis; mandibulorum dente tuberculoque magnis; laminis dentalibus margine antico fere recto; dentibus 6, nigris, magnis, utrinque duobus intimis coadunatis, externo sejuncto, conico; scutis interdum postice viridi marginatis; spiraculis anticis maximis; pedibus luteolis, longis, compressis, paris penultimi articulo basali spinis 5 in processu angulari terminali alterisque 1—2 armato; pari postremo valde elongato, subcylindrico, haud compresso, articulo basali tibiali multo longiore, 30—45 spinis longitudinaliter seriatis armato; processu angulari magno, spinis 6—8; appendicibus analibus lateralibus dense punctatis, elongatis, singula spinis apicalibus 8—12 et interdum alteris marginalibus 1—4.

Chestnut, robust; head chestnut, large; cephalic segment ovate, sparsely minutely punctate; basal segment very large; antennæ 17 articulate; mandibular tooth and tubercle large; dental laminæ with their anterior margin almost straight; teeth 6, black, large, the two inner on each side coadnate, the external distant, conical; scuta sometimes margined posteriorly with green; anterior spiracles very large; feet yellowish, long, compressed, basal

* "S. INEQUIDENTU (S. INÆQUIDENS).—Tête subcordiforme un peu-élargie; doubles stries dorsales parallèles continues en dessus, assez peu marquèes; bord postèrieur du dernier segment triangulaire obtus; stries inférieurs faiblement divergentes; plaques des segments subarrondies à leur bord postérieur; plaque prèanale quadrilatère ètroite á bord postérieur plus étroit que l'antêrieur, droit; angles subarrondis; pièces latèrales terminèes en èpine multifide tres-finement ponctuées; antennes longues, nues; sallies dentiféres finement ponctuées, à trois dent inègales, l'interne large, à bord libre rectiligne, la mitoyenne peu distincte, subarrondie, l'externe sèparèe par un espace plus grand; pieds de derrière assez longs, forts, subarrondis, èpineux en dessous et á la face interne; 6 èpines environs en dessous; et à peu près 14 au bord interne, la dernière multifide, á sept petites pointes inègales en couronne. Couleur ferrugineuse un peu nuancèe de verdâtre; antennes pâles; tête, segment forcipulaire et partie postèrieur plus ferrugineuse. Longeur de corps, 0.190; plus grande largeur, 0.022. Antennes, 0.035; pieds de derrière, 0.035."

"Des Etats Unis, á New-York, par M. Milbert (Muséum de Paris, 1824)."

joint of penultimate pair armed with 5 spines on a terminal angular process and 1—2 others; last pair very elongate, subcylindrical, not compressed, basal joint much longer than the tibial, armed with 30—45 spines in longitudinal series; angular process large, with 6—8 spines; lateral anal appendages densely punctate, elongate, each with 8—12 apical spines, and sometimes 1—4 marginal.

S. LONGIPES, *Wood*, Journ. A. N. S., New Series, 1863, vol. v, p. 26.

This species is closely allied to *S. alternans*, Leach, but differs from the characters given by Mr. Newport; first, in the mandibular tubercle (mandibular tooth of Newport), being very large and having the lesser tubercle near to its base; secondly, in the number of spines on the basal joint of last pair of legs being from 30—45 instead of from 45—60; and finally, by the roughness of the lateral anal appendages. Besides, the specimens agree in possessing important characters not mentioned by Mr. Newport, and which it is fair to conclude do not exist in his species.

The head and its appendages are very large and stout. The antennæ are generally lighter in color than the body. The first scutum is much the smallest. The lateral margins of the anterior scuta are straighter than those of the posterior, which are elevated. The posterior margin of the terminal scutum is very strongly arcuate. The scuto-episcutal sutures are traceable, but not so well marked as the sterno-episternal. The femur of the nineteenth pair of legs is furnished with two small spines on its distal extremity; that of the twentieth with one or two on its upper surface, and a well-marked terminal angular process supporting five small spines. The femur of the last pair is rather depressed than compressed, and armed with 30—45 small spines, irregularly arranged in rows on its upper, inner, and lower surfaces. The preanal scale is somewhat elongate, and narrowed posteriorly.

Hab. Florida.—Smithsonian Collection.

S. BYSSINA.

S. saturate viridis aut brunnea; capite dilute castaneo, et labio mandibulisque sparse punctatis; segmento cephalico late ovato, antice leviter emarginato, segmento prebasali nullo; antennis luteolis, 18 articulatis, pubescentibus; dente mandibulari gracile; laminis dentalibus latis; dentibus labialibus 10, parvis, nigris, utrinque tribus intimis coadunatis; pedibus gracilibus, luteolis, modice compressis; pare postremo supra complanato, subtus valde convexo, marginibus superioribus et externo et interno acutis; articulo basali tibiali longiore et intus et subtus bi- vel tri-spinoso, processu angulari bifido vel trifido; superficie ventrali brunneo-olivacea; appendicibus analibus lateralibus profunde dense punctatis, modice elongatis, singula spinis apicalibus 2—3, apicibus haud incurvatis.

Deep green or brown; head light chestnut, with the labium and mandibles sparsely punctate; cephalic segment broadly ovate, anteriorly slightly emarginate, prebasal segment wanting; antennæ yellowish, 18 articulate, pubescent; mandibular tooth slender; dental laminæ broad; labial teeth 10, small, black, the inner three on each side

coadnate; feet slender, yellowish, moderately compressed; last pair of feet above complanate, below strongly convex, superior margins, both external and internal, acute; basal joint longer than the tibial, both on the inner and lower surface bi- or tri-spinous, angular process bifid or trifid; ventral surface brownish-olive; lateral anal appendages densely profoundly punctate, rather elongate, each with 2—3 apical spines, apex not incurvate.

S. BYSSINA, *Wood*, Proc. Acad. Nat. Sci., 1861, p. 10; Journ. A. N. S., 1863, p. 26.

The head is of moderate size. The dental lamina are rather broad, their teeth small, almost tuberculiform. The scuto-episcutal sutures are traceable, but not so distinct as the sterno-episternal. The first scutum is very short, the penultimate very large, with its sides strongly arched. The legs are slightly compressed. One brown specimen has some of its scuta margined posteriorly with green. This species differs from *subspinipes* in the shape of hind pair of legs, which are parallelopipedal, and have the margins much more acute, as well as in the proportionate length of the basal and tibial joints. How far these characters are specific is not certain, and it is very possible that this species does not deserve to rank higher than a variety. Large suites of specimens can alone decide this.

The *habitat* of *S. byssina* is uncertain. Originally it was described as doubtfully living in Florida. Then specimens were found in the Smithsonian Collection labelled California. Since then others have come to light labelled Florida. It is hardly possible that the species is common to the two countries, and which is correct I am at a loss to decide. Length 2½ inches.

S. COPEANA.

S. luteolo-castanea prasino sparsa; capite sparse minute punctato; segmento cephalico parvo, subrotundo, convexo; basali magno; antennis 25 articulatis; labio rubri-castaneo; laminis dentalibus subelongatis, margine antico fere recto; dentibus 8, nigris, utrinque duobus intimis coadunatis, extimis duobus majoribus, conicis, sejunctis; pedibus luteolis, modice compressis; pari postremo robusto, articulo basali tibiali vix longiore, supra complanato, intus 4—6 spinis, infra 9—17 spinis in serie quadruplici (interdum inordinatim) dispositis; processu angulari spinis 2—5; appendicibus analibus lateralibus dense profundeque punctatis, singula spinis apicalibus 3—5, et marginalibus 1—3; superficie ventrali sordide luteola.

Yellowish-chestnut, sprinkled with light green; head sparsely minutely punctate; cephalic segment small, subround, convex; basal large; antennæ 25 articulate; labium reddish-chestnut; dental laminæ subelongate, with their dental margins nearly straight; teeth 8, black, the two inner on each side coadnate, the two external larger, conical, distant; feet yellowish, moderately compressed; last pair robust, basal article scarcely longer than the tibial, above complanate, within 4—6 spines, below 9—17 spines arranged in a fourfold series (sometimes irregular); angular process with from 2—5 spines; lateral anal appendages densely profoundly punctate, each with 3—5 apical spines and 1—3 marginal; ventral surface a dirty yellow.

S. COPEANA, *Wood*, Journ. Acad. Nat. Sci., New Series, vol. v, 1863, p. 27.

The head is somewhat peculiar; it is not so broad as the posterior portion of the body.

The cephalic segment is convex, subround, sometimes somewhat truncate posteriorly. Its breadth is just about equal to its length, but owing to the convexity appears less. The basilar segment is much larger than the cephalic, and has the prebasilar fold well marked. The posterior portion of the scuta are often margined with green, and, in some specimens, the anterior part of the body is mottled with this color. In one individual the antennæ are of a pea-green tint; generally they correspond in color with the feet. The penultimate scutum is large, with its lateral margins strongly arched. The terminal scutum is medianly slightly subcarinate. The sterno-episternal sutures are better marked than the scuto-episcutal, which are, however, quite evident. It is noticeable that the terminal scutum has a single median, instead of two lateral sutures. The preanal scale is rather large, much narrowed, and very slightly emarginate posteriorly. Where the marginal spines of the lateral anal appendages exceed two in number, some of them are generally very small and situated at or near the base of the terminal process. I have named this species in honor of Prof. Edward D. Cope, with whom it has been my good fortune to have been associated since the earliest dawn of our tastes for natural history.

Length 4½ inches.

TABLE SHOWING VARIATIONS IN SPECIFIC CHARACTERS.

Number of specimen.	Labial teeth.	Spines on inner side of basal joint of last pair of legs.	Spines on lower surface of basal joint of last pair of legs.	Spines on angular process.	Spines on anal appendages.	
					Apical.	Marginal.
39	4	4	2 2 3 2	2	4	2
	4	5	2 2 2 4	3	4	2
309	4	6	4 4 5 4	5	5	2
	4	6	3 3 4 3	5	3	1
	4	4	2 3 5 3	2	4	1
	4	4	2 3 5 3	2	5	3
	4	6	3 3 1 5 3	4	5	3
	4	5	1 3 2 3 3	4	5	3
	4	6	3 2 3 3	3	6	1
	4	6	2 2 3 4	2	4	2
	4	5	2 3 4 3	3	3	1
	4	5	2 3 3 3	3	4	1
	4	5	1 2 4 3	3	4	1
	4	5	2 2 3 3	3	3	2

Hab. California.—Smithsonian Collection.

S. BISPINIPES.

S. olivacea, polita; capite olivaceo-castaneo; mandibulis magnis; segmento cephalico late ovato, antice leviter emarginato, basali magno, prebasali nullo; antennis 19 articulatis, antice pubescentibus; labio leviter convexo, sine suturis, minute punctato; laminis dentalibus, latis, brevibus, marginibus anticis rectis, angulis posticis externis productis; denticulis 10, conicis, parvis sed acutibus et distinctis, utrinque intimis tribus arcte coadunatis, duobus externis sejunctis; suturis scuto-episcutalibus inconspicuis, sed sterno-episternalibus modice conspicuis; pedibus

luteolis, leviter compressis; pari postremo gracile, articulo basali supra complanato, subtus valde convexo et sine spina, intus bispinoso, margine superiore externo acuto; processu angulari valde elongato, simplice vel bifido; articulo tibiali basali fere æquale, sed subcylindrico et graciliore; appendicibus analibus lateralibus longis, dense minute profunde punctatis, utrinque spinis apicalibus 1—3.

Olive, polished; head olive-chestnut; mandibles large; cephalic segment broadly ovate, anteriorly slightly emarginate, the basal segment large, prebasal absent; antennæ 19 articulate, distally pubescent; labium slightly convex, without sutures, minutely punctate; dental laminæ broad, short, with their anterior margins straight, the external posterior angles produced; denticules 10, conical, small but acute and distinct, the inmost three on each side closely coadnate, the outer two separate; scuto-episcutal sutures not conspicuous, but the sterno-episternal rather so; feet yellowish, slightly compressed; last pair slender, the basal joint above complanate, below strongly convex and without spines, within bispinous, the superior external margin acute, the angular process very elongate, simple or bifid; tibial joint about equal to the basal, but subcylindrical and more slender; lateral anal appendages long, densely minutely profoundly punctate, on each side with from 1—3 apical spines.

S. BISPINIPES, *Wood*, Journ. A. N. S., New Series, 1863, p. 28.

The length of cephalic segment is equal to its breadth. The mandibles are thick. The breadth of the dental laminæ much exceeds their length. The teeth are small, but very distinct. The penultimate scutum is large, with its lateral margins strongly arched; the terminal is large, with its lateral margins arched, very strongly elevated, and its posterior very arcuate. The preanal scale is not canaliculate, but much narrowed posteriorly, with its margins very nearly straight. The spines on the basal articulation of the last pair of feet are very large; the anterior is situated above the other. This species is closely allied to *S. Newportii*, Lucas (originally described by Mr. Newport as *S. Gervaisii*). Mr. Newport, in his latin diagnosis, both in the Linnæan Transactions and the Catalogue of the British Museum, says "*dentibus conspicuis*," but in the former work he says, "The most marked character of this species is the *indistinctness* of the labial teeth, which in some specimens are *entirely wanting!*" What does he mean? This species is also allied to *S. ornata*, Newport. That author states, "pedum paris postremi articulo basali *spinis tribus* acutis," but does not state the form of the head. Afterwards he says: "This is a very beautiful species, very distinct in every respect of form, size, and shape of the head from *S. subspinipes*, but *precisely similar* as regards the shape and *armature* of posterior pair of legs," &c. Now, *S. subspinipes* is furnished with *five spines* on its posterior pair of legs! The specimens before me may belong to *S. ornata*, but their heads do not differ from those of *S. subspinipes*, and it is not clear what the armature of *S. ornata* really consists of. I have seen two specimens from San Francisco, belonging to the Museum of Comparative Zoology.

Gen. 4. CRYPTOPS, *Leach.**

Segmenta podophora 21. Antennæ 17 articulatæ. Oculi nulli vel inconspicui. Labium edentulum. Scutum postremum Scolopendræ veræ illo simillimum. Pedum postremorum articulus basalis plerumque inermis. Appendices anales laterales obtusæ.

Feet-bearing segments 21. Antennæ 17 articulate. Eyes absent or inconspicuous. Labium edentate. Last scutum similar to that of the true Scolopendra. Basal joint of the last pair of feet generally unarmed. Lateral anal appendages obtuse.

"Cryptops hyalina.

"Pallida, lævis, lineis 2 longitudinalibus saturatioribus; capite antennisque ferrugineis; pedibus postremis brunneis spinulis 5 in articulo tertio tarsalive. Long. lin. 7."

Pale, smooth, with 2 deeper longitudinal lines; head and antenna ferruginous; last pair of feet brown, with 5 spinules on the third or tarsal joint. Length 7 lines.

"Crypt. hyalina, *Say*, Journ. Acad. Nat. Sci., 1st series, vol. ii; id. Œuvr. Entom. 1, sp. 23; *Gerv.* in Ann. Sci. Nat., Janv. 1837, sp. 3; *Lucas*, Hist. Nat. Anim. Artic. p. 546, sp. 3."

"*Hab.* In Georgiâ et Floridâ."

Species mihi ignota.

"C. Milbertii, *Gervais.*

"Point d'yeux; 22 segments, en comptant la tête d'un brun marron. Tête arrondie, non engagée dans le second segment. Plaques convexes non arrondies à leurs bords postérieurs, bordées. Segments très inéguax entre eux, les 1, 3, 5, 6, 8, 10, 12, 14, 16, 18, sont les moins allongés; le dernier est plus étroits et cylindröide. En dessous, ces plaques sont un peu bombées et presque égales. Les deux paires de pattes postérieures sont plus allongées que les autres et terminées par une petite griffe; mais les cuisses ne sont point renflées ni beaucoup plus grosses que celles des autres pattes, et celles des pattes postérieures n'ont ni èpines ni tubercules. Les mâchoires (ou les mandibules des auteurs) sont brunes, comme le menton ou la lèvre qui supporte les crochets des mandibules. Cette lèvre n'est point bifide, mais arrondie à son extrémitié; elle n'a point de dents, mais seulement deux enfoncements latéraux. Les mandibules ou palpes ont leurs articles cylindriques et rougeâtres; le dernier article est comme tronquè et terminé par une pointe ou onglet. Les antennes sont allongées et quand on les renverse en arrière, elles atteignent le millieu du cinquième segment; leurs articles courts, renflès, moniliformes, très-règuliers, presque ègaux, sont au nombre de 17.

"Apporte de Jersey dans l'Amérique du Nord par M. Milbert. Cette espèce diffère de l'Hortensis par des pattes beaucoup plus comtes et une tête plus arrondie."

Species mihi ignota.

C. Milberti, *Gervais*, Apt. iv, p. 592.

* Linn. Trans. xi, p. 384.

Gen. 5. OPISTHEMEGA.*

Segmenta podophora 21. Ocelli nulli. Labium plerumque dentatum. Scutum postremum maximum, quadratum, alteris multo majore; pedes postremi crassi, breves. Appendices anales laterales obtusæ. (Figs. 8, 9, 10.)

Feet-bearing segments 21. Eyes absent. Labium generally dentate. Last scutum very large, quadrate, much larger than the others; last pair of feet thick, short. Lateral anal appendages obtuse.

O. postica.

O. aurantiaca; capite polito, punctato; segmento basali depressione triangulari mediana; labio antice elongato, mandibulisque punctatis; laminis dentalibus subelongatis, margine antico fere recto; denticulis 6, distinctis, acutis; antennis haud pubescentibus, 17 articulatis; scutis sternisque politis; scuto postremo subprofunde punctato, postice abrupte truncato, medio canaliculato, lateribus rotundatis, marginibus lateralibus valde elevatis; pedibus postremis brevissimis, subprofunde punctatis, subcylindricis; articulis basali tibialique sine spinis, supra subcomplanatis, intus complanatis, margine interiore superiore acuto, alteris rotundatis; appendicibus analibus lateralibus angustis, dense profunde punctatis, postice abrupte truncatis, sine spinis; squama preanali elongata, media vix canaliculata.

Fig. 8.



Fig. 9.



Orange; head polished, punctate; basal segment with a median triangular depression; labium anteriorly elongate, together with the mandibles punctate; dental lamina somewhat elongate, anterior margin almost straight; denticules 6, distinct, acute; antennæ not pubescent, 17 articulate; scuta and sterna polished; last scutum subprofoundly punctate, posteriorly abruptly truncate, medianly canaliculate, with the sides rounded, lateral margins very elongate; last pair of feet very short, subprofoundly punctate, subcylindrical; basal and tibial joints without spines, above subcomplanate, within complanate, superior interior margin acute, the others rounded; lateral anal appendages narrow, densely profoundly punctate, posteriorly abruptly truncate, without spines; preanal scale elongate, medianly scarcely canaliculate.

O. postica, *Wood*, Journ. A. N. S., new series, 1863, vol. v, p. 35.

From the triangular depression on the basilar segment two sutures diverge posteriorly. The scuto-episcutal sutures are very distinct, the sterno-episternal wanting. The sterna are, however, provided with a mesial marking, the line of coalescence of the two primitive sterna. The last pair of feet are rather shorter than in the following species, more cylindrical and smoother, especially on their inner surface. The basal joint is rather shorter than the tibial, which is about twice as long as the tarsal. Can this be the same species as *Cryptops postica*, Say? It agrees with Mr. Newport's description of his *Thea-*

* Wood, Journ. A. N. S., new series, 1863, vol. v, p. 35. *Οπισθε*, postice, *μεγας*.

tops postica (*C. postica*, Say), except as to the eyes and teeth. Is it possible that Mr. Newport is mistaken as to the possession of eyes? Say certainly did not see them. Length 1¾ inches.

Hab. North Carolina.—Dr. Wm. Stimpson.—Smithsonian Collection.

O. SPINICAUDA.

O. aurantiaca; capite polito, punctato; segmento basali depressione magna triangulari mediana; antennis 17 articulatis, antice pubescentibus; laminis dentalibus, labio mandibulisque subprofunde punctatis, margine antico rotundato; denticulis labialibus 4, parvis, arcte coadunatis, indistinctissimis; labio medio antice subcarinato; scuto postremo maximo, subprofunde punctato, alteris fere bis majore, lateribus rotundatis, marginibus lateralibus valde elevatis; pedibus postremis robustis, supra complanatis, intus complanatis et rude punctatis, articulo basali tibiali fere æquali; femore, tibia, tarsisque margine interiore superiore acuto et serrulato, femore tibiaque margine interiore inferiore quoque acuto et serrulato; processu angulari parvo, spina unica robusta acuta; appendicibus analibus lateralibus angustis, postice truncatis, dense profunde punctatis, singula spina unica apicali minutissima; squama preanali elongata, subprofunde punctata, media leviter canaliculata. (Figs. 8, 9, 10, 11.)

Orange; head polished, punctate; basal segment with a large median triangular depression; antennæ 16 articulate, distally pubescent; dental lamina, with the labium and mandibles subprofoundly punctate, anterior margin rounded; labial denticules 4, small, closely coadnate, very indistinct; labium medianly anteriorly subcarinate; last scutum very large, subprofoundly punctate, almost twice as large as the others, with its sides rounded, its lateral margins very much elevated; last pair of feet robust, above complanate, within complanate and rudely punctate; basal and tibial joints about equal; interior superior margin of the femur, tibia and tarsi acute and serrulate; the interior inferior margin of the femur and tibia also acute and serrulate; angular process small, with a single acute robust spine; lateral anal appendages narrow, posteriorly truncate, densely profoundly punctate, each with a very minute apical spine; preanal scale elongate, subprofoundly punctate, medianly lightly canaliculate.

Fig. 10.



Fig 11.



O. SPINICAUDA, *Wood*, Journ. A. N. S., new series, vol. v, 1863, p. 36.

The color varies greatly in depth of shade, but the two ends are almost always darker than the intermediate portion of the body; the feet, with the exception of the last pair, are generally lighter. The cephalic segment is slightly emarginate in front. The suture between the true basilar segment and the prebasilar fold is very deep; it is formed by two lines rapidly divergent from the centre, and at the central portion there is quite a large triangular depression. In some specimens the scuto-episcutal sutures are well-marked. The posterior borders of the scuta are straight. The terminal scutum is nearly twice as large

as any of the others, deeply punctate, and without a sulcus or any traces of the sutures. The last pair of legs are dark in color, short and very robust; their basilar joint is often furnished with one or two small spines, besides the terminal, on either the inferior or superior internal margin. They present the peculiar crossing of the nails found in the other species. The other legs are somewhat compressed. Length, 2¼ inches.

Hab. South Illinois, West Pennsylvania. Smithsonian Collection.

Gen. 6. THEATOPS, *Newp.**

"Ocelli distincti. Antennæ breves, subulatæ, 17—articulatæ. Segmentum cephalicum truncatum subimbricatum; margine labiali denticulato. Pedum postremorum articulus magnus, obconicus, abbreviatus. Pedum paria 21. Appendices anales laterales obtusæ."

Eyes distinct. Antennæ short, subulate, 17 articulate. Segments cephalic, truncate, subimbricate; labial margin denticulate. Joint of the last feet large, obconical, abbreviated. Pairs of feet 21. Lateral anal appendages obtuse.

T. postica.

"T. aurantiaca, ocellis inconspicuis lateralibus, dentibus 8 minutis, segmento postremo maximo elongato quadrato lateribus rotundato medio profunde sulcato margine posteriore transverso, pedibus postremis brevibus crassis rotundatis attenuatis; articulo basali brevissimo. Long. unc. 8–10."

Orange, ocelli lateral not conspicuous; teeth 8 minute; last segment very large, elongate, quadrate, with its sides rounded medianly; profoundly sulcate, with its posterior margin transverse; last feet short, thick, rounded attenuate; basal joint very short. Length, 8–10 inches.

Crypt. postica, *Say*, Journ. A. N. S., Philada., ii, p. 112; Œuvr. Entom. i, p. 24; Gervais, Ann. Sci. Nat. Janv., 1837, p. 51, sp. 5; Apt. iv, p. 294.
" *Lucas*, Hist. Nat. Anim. Artic., p. 547, sp. 5.
" *Newport*, Ann. Mag. Nat. Hist., xiii, p. 110.

Theatops postica, *Newport*, Linn, Trans., xix, p. 410; Catal. British Mus. (Myriap.), p. 61.
" *Wood*, Journ. A. N. S., new series, vol. v, 1863, p. 37.

"*Hab.* In Georgia, Floridaque Orientali."

"The mandibles are short, thick, and have a distinct basal tooth; the dental plates are elongated and widely separated; the teeth 8, minute but distinct. The basal joint of the posterior pair of legs much shorter than the second, which is twice as long as the succeeding joints. The lateral anal appendages deeply punctured. Preanal scale flat, with a median longitudinal sulcus and scattered punctures, with the margin straight."

I have never seen a specimen of this species.

* Linn. Trans., xix, p. 410.

Gen. 8. SCOLOPOCRYPTOPS, *Newp.**

Ocelli nulli, segmenta podophora 23, postremum angustum; segmentum cephalicum imbricatum. Labium edentulum. Antennæ 17 articulatæ.

Eyes none; feet-bearing segments, 23; the last narrow; cephalic segment imbricate. Labium edentate. Antennæ, 17 articulate.

S. SEXSPINOSA.

S. saturate aurantiaca; pedibus flavis, subcompressis; antennis flavis, interdum aurantiacis, pubescentibus; capite labio mandibulis scutis sternisque punctatis; segmento cephalico subovato; labii margine antico fere recto; scuto postremo angusto, longo; pedibus postremis elongatis, haud pilosis; articulo basali tibiali longiore, spina unica magna in superficie inferiore et altera minore mediana in margine superiore interno et rare altera articulari minutissima; appendicibus analibus lateralibus valde elongatis, profunde dense punctatis, singula spina apicali unica alteraque minutissima in angula superiore posteriore; squama preanali postice vix emarginata. (Fig. 12.)

Fig. 12.

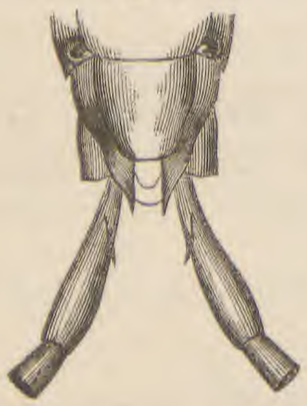


Fig. 13.



Deep orange; feet yellow, somewhat compressed; antennæ yellow, sometimes orange, pubescent; head, labium, mandibles, scuta, and sterna punctate; cephalic segment subovate; anterior margin of the labium (Fig. 13) nearly straight; last scutum narrow, long; last feet elongate, not pilose; the basal joint longer than the tibial, with one large spine upon its inferior surface, and another smaller median on its inner superior margin, and rarely a third very small articular; lateral anal appendages very elongate, densely profoundly punctate, each with a single apical spine, and another very minute one upon their superior posterior angle; preanal scale posteriorly scarcely emarginate.

Cryptops sexspinosus. *Say*, Journ. Acad. Nat. Sci., ii, p. 112, 1821; Id. (Lequien ed.) Œuvres Entom. i, p. 24; Gervais, Ann. Nat. Janvr., 1837, p. 51.
" " *Lucas*, Hist. Nat. Anim. Art., p. 547.
" " *Newport*, in Ann. and Mag. Nat. Hist., xiii, p. 100.

Scolopocryp. sexspinosa, *Newport*, Linn. Trans., xix, p. 407.
" " *Gervais*, Apt. iv, p. 297, et Tabl. Myriap. Amer. (Exp. Ameriq. de Sud, part. sept.), p. 36.
" " *Wood*, Journ. A. N. S., 1863, p. 37.

In this species the superior spine of the lateral anal appendages is very minute, and occasionally present only on one side. The color varies from milk-white to a dark reddish orange. The lighter shades are found in those individuals which have recently shed their skins. The color given in the diagnosis may be considered as that which characterizes the species, being the one to which it finally attains. The inferior surfaces of the posterior

* Linn. Trans., vol. xix, pp. 275, 405.

legs are marked with an elongate whitish blotch. The preanal scale is rather short, and much narrowed posteriorly. I have examined a number of specimens, and have found the articular spine in few. I recently observed an individual just completing the operation of shedding his skin. This was crowded back so as to cover only the last two or three segments, giving the animal a very peculiar appearance. He soon, however, with many contortions, drew himself out of the old garment. On examining it, I found that it contained the derm of the head and all its appendages, even to the maxillæ and maxillary palpi. The anterior portion of the skin was so torn as to show that the process of shedding probably commenced by the creature's withdrawing its head from its case, and then thrusting it out between some of the anterior sterna, completing the process by pushing the skin back with its legs aiding them by a peculiar wriggling motion. The exuvia has most of the posterior segments entire, showing that the occupant has been withdrawn from it like a hand from a glove. The animal is of a milk-white color, with the antennæ pubescent, and the lateral anal appendages not elongate and without spines. The lower spine on basal joint of last pair of legs is very small, and the upper one scarcely perceptible. I once had the pleasure of observing a female guarding the young. She laid on her side, with her body coiled around them, and, by a rapid, cilia-like action of her feet, would pass them along and arrange them to suit her. This species is one of the most common chilopods around Philadelphia. The Southern specimens are much larger, stouter, and more highly colored than those from colder regions. Length, 2 inches.

Hab. The Atlantic United States.

S. GRACILIS.

S. ferruginea; capite labioque leviter punctatis, segmento-cephalico subovato; antennis pubescentibus; labii margine antico modice angusto, lateribus obliquis apice emarginato et angulis acutis; pedibus flavis, subcompressis; scutis sternisque vix punctatis; pedibus postremis gracilibus, elongatis, singulo spinis duabus S. sexspinosæ illis similimis, articulo basali tibiali longiore, articulis tribus ultimis pubescentibus; appendicibus analibus lateralibus elongatis, rude punctatis, singula spina apicali unica (interdum bifida) alteraque minutissima in angulo superiore posteriore; squama preanali elongata, punctata, postice late emarginata. (Fig. 14.)

Ferruginous; head and labium lightly punctate, cephalic segment subovate; antennæ pubescent; anterior margin of the labium rather narrow, with oblique sides, emarginate apex, and acute angles; feet yellow, subcompressed; scuta and sterna scarcely punctate; last feet slender, elongate, each with two spines very similar to those of S. sexspinosa; basal joint longer than the tibial; three last joints pubescent; lateral anal appendages elongate, rudely punctate, each with a single apical spine (sometimes bifid), and another, very minute, upon the superior posterior angle; preanal scale elongate, punctate, posteriorly broadly emarginate.

S. GRACILIS, *Wood*, Journ. A. N. S., new series, 1863, vol. v, p. 38.

The color in all of our specimens is lighter and more ferruginous than the typical color

of *S. sexspinosa*, but further investigations may show that that of this form also darkens with age. The prebasilar fold is generally well marked. The scuto-episcutal sutures are distinct; the sterno-episternal absent; but a suture marking the line of coalescence of the primitive sterna is often very apparent. This species is closely allied to the preceding as well as to the following. It differs from both in the shape of the anterior margin of the labium (Fig. 14), in the scarcity of punctations on the body, and in the pubescence of the distal portion of the last pair of feet. The superior spine of the lateral anal appendages is perhaps a little larger than in *S. sexspinosa*, but certainly smaller than in *S. spinicauda*. The white blotches beneath the posterior feet are common to all the North American species. Length, 2 inches.

Fig. 14.



Hab. Fort Tejon, California. S. Xantus.—Smithsonian Collection.

S. SPINICAUDA.

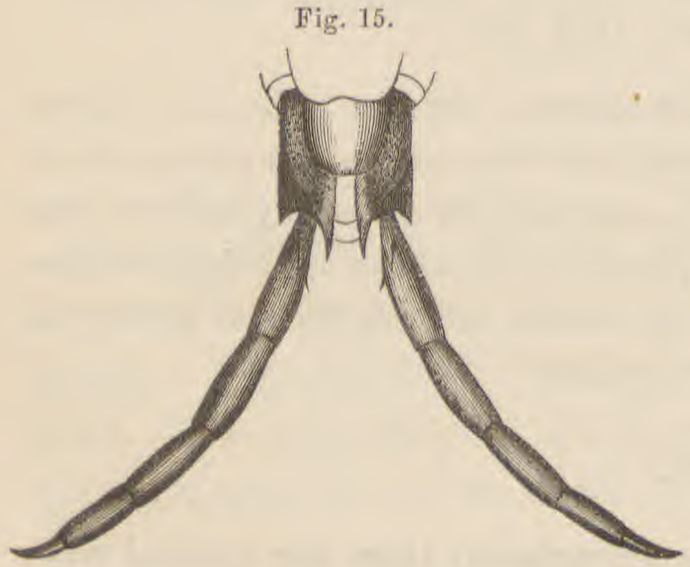
S. aurantiaca, polita; capite labio mandibulis sternisque profunde punctatis; segmento-cephalico subovato; antennis pubescentibus; labii margine antico lato, fere recto, medio vix emarginato; scutis modice rugosis, punctatis, marginibus lateralibus elevatis; pedibus postremis elongatis, gracilibus, spinis duabus S. sexspinosæ illis similimis, articulo basali tibiali longiore; appendicibus analibus lateralibus valde elongatis, rude punctatis, singula spina apicali unica alteraque in angulo posteriore superiore; squama preanali modice breve, postice rotundata, vix emarginata. (Fig. 15.)

Orange, polished; head, labium, mandibles, and sterna profoundly punctate; cephalic segment subovate; antennæ pubescent; anterior margin of the labium broad, almost straight, medianly scarcely emarginate; scuta moderately rugous, punctate, with elevated lateral margins; last feet elongate, slender, with two spines very similar to those of S. sexspinosa; basal joint longer than the tibial; lateral anal appendages very elongate, rudely punctate; each with a single apical spine, and another upon the posterior superior angle; preanal scale rather short, posteriorly rounded, scarcely emarginate.

S. SPINICAUDA, *Wood*, Journ. A. N. S., 1863, new series, vol. v, p. 39.

The head is deeply punctate. The scuta are somewhat rugous with the scuto-episcutal sutures traceable. The sterna are without any traces of sutures. The whole body is more or less deeply punctate. The superior posterior angle of the lateral anal appendages is slightly prolonged and armed with a rather small black spine, which is, however, considerably larger than in any other species known to me. The posterior legs are exactly like those of *S. sexspinosa*, Newp. Length, 2 inches.

Fig. 15.



Hab. Washington Territory, Oregon.—Drs. Cooper and Kinnerly.—Smithsonian Collection.

S. LANATIPES.

S. aurantiaca; pedibus compressis, flavis; capite mandibulis labio sternisque minute punctatis; segmento cephalico subovato; labio medio emarginato fere sicut in S. gracile, margine antico rotundato; pedibus postremis modice robustis, singulo spinis duabus S. sexspinosæ illis similimis, articulo tibiali basali fere æquali; tibia tarso metatarsoque pubescentibus; appendicibus analibus lateralibus brevibus, rude punctatis, singula spina apicali alteraque minutissima in angulo superiore posteriore; squama preanali modice lata, convexa, margine postico interdum late emarginato. (Figs. 16, 17.)

Orange; feet compressed, yellow; head, mandibles, labium, and sterna minutely punctate; cephalic segment subovate; labium medianly emarginate, almost as in S. gracile, the anterior margin rounded; last feet rather robust, each with two spines similar to those of S. sexspinosa; tibial and basal joints about equal; tibia, tarsus, and metatarsus pubescent; lateral anal appendages short, rudely punctate; each with an apical spine, and another very minute one upon the superior posterior angle; preanal scale rather broad, convex; its posterior margin sometimes broadly emarginate.

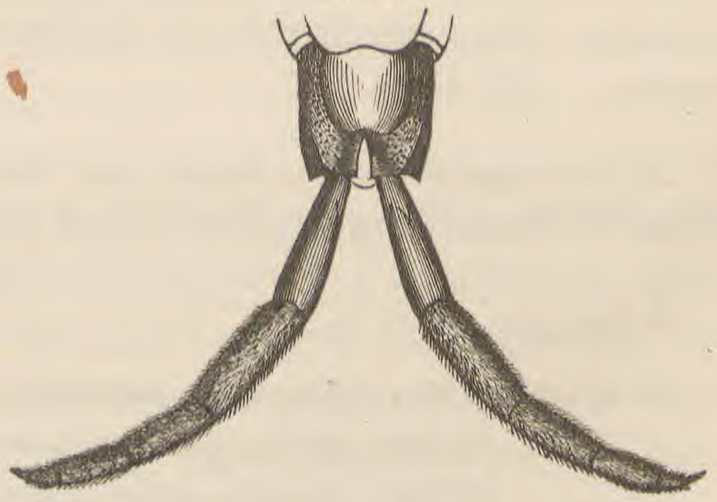
S. LANATIPES, *Wood*, Journ. A. N. S., new series, vol. v, 1863, p. 39.

This species is closely allied to *S. gracilis*, and it is possible that further specimens may show that the characters on which I rely in separating them vary. The differences are as follows: The labium (Fig. 16) closely resembles that of the first described species, but has the character not so well marked. The posterior pair of legs are more robust, with the tibia about equal to the femur in length, and pubescent. The lateral anal appendages are shorter and separated inferiorly by a much narrower space. The preanal scale is rather broader and more bent over the lateral anal appendages; and, finally, this species seems to attain to a larger size. Length, 2¼ inches.

Fig. 16.



Fig. 17.



Hab. California.—Smithsonian Collection.

FAM. V. GEOPHILIDÆ, *Leach.**

Segmenta numerosa, singulum subsegmentis duobus completis sed inæqualibus efformatum, et pedum par unicum gerens. Oculi nulli. Antennæ 14 articulatæ. Pedes anales breves, styliformes.

Segments numerous; each formed of two complete but unequal subsegments, and bearing a single pair of feet. Eyes wanting. Antennæ 14 articulate. Anal feet short, styliform.

* Linn. Trans., vol. xi.

The family character of this group which first attracts attention, is the large number of segments, each of which is composed of two unequal subsegments. The boundaries of the respective scuta of each pair of the latter are well marked by sutures, &c., but the sterna are completely consolidated. The head varies in form, size, &c., and furnishes the principal generic characters. The number of joints of the antennæ is fixed for the family, but nevertheless good specific, and even generic, characters, are derivable from these organs. The most important specific characters besides those before alluded to are founded upon, firstly, the peculiarities as to size, shape, proportion, &c., of the component portions of the head and its appendages; secondly, the color and form of the body, and the number of segments composing it; thirdly, the structure of the legs, especially of the last pair; and, finally, the markings and sutures of the scuta and sterna. I have never had an opportunity of examining very large suites of specimens, so as to determine positively the constancy of the various characters enumerated, but they probably do not vary a great deal.

Gen. 1. MECISTOCEPHALUS, *Newp.**

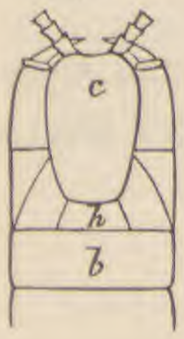
Segmentum cephalicum elongatum, angustum, latitudine plus duplo longius. Antennæ approximatæ, articulis obconicis. Subsegmentum prebasale sejunctum sed basale subbasaleque coalita. Mandibulæ magnæ, intus denticulatæ. (Fig. 18.)

Cephalic segment elongate, narrow, more than twice as long as broad. Antennæ approximate; articles obconic. Prebasal subsegment separate, but the basal and subbasal coalescent. Mandibles large, within denticulate.

M. FULVUS.

M. fulvus, politus; capite dilute aurantiaco, punctato, pilis longis rigidis paucis; segmento cephalico antice truncato, postice illico angustato et vix truncato; antennis longis, pilis longis rigidis multis; labio profunde punctato, antice emarginato, medio sulco impresso; mandibulis distincte punctatis, pilis rigidis paucis, quadridentatis; segmento anali piloso; pedibus pilis longis, paribus 57.

Fig. 18.



Fulvous, polished; head light orange, punctate, with a few long rigid hairs; cephalic segment anteriorly truncate; posteriorly rapidly narrowed and scarcely truncate; antennæ with many long rigid hairs; labium profoundly punctate, anteriorly emarginate, impressed with a median sulcus; mandibles distinctly punctate, with a few rigid hairs, quadridentate; anal segment pilose; feet with long hairs, 57 pairs.

M. FULVUS, *Wood*, Journ. A. N. S., new series, 1863, vol. v, p. 41.

? GEOPHILUS ATTENUATUS, *Say*, Journ. A. N. S., 1st series, vol. ii.

The cephalic segment is scarcely narrowed at all, except at the posterior end, where it is rapidly contracted, being indeed rounded off. The body is slender and polished. The

* Proc. Zool. Society, December, 1842, p. 179.

scuto-episcutal and sterno-episternal sutures are very distinct, as well as those between the primitive sterna. I have found this species around Philadelphia, although not very abundantly. They appear to affect the inner bark or liber of decaying logs, especially that of the locust (*Robinia pseudacacia*, L.) I have, however, occasionally observed them under stones. It may possibly be *Geophilus attenuatus*, but that species can never be determined from Say's description.

M. MELANONOTUS.

M. parvus, gracilis, dilute aurantiacus; lineis duabus dorsalibus, latis, nigris, e capite ad segmentum penultimum ductis; capite sparse breve piloso; antennis sparse pilosis; labio, medio valde canaliculato, utrinque maculis tribus nigris; mandibulis intus vix denticulatis; lateribus nigro maculatis; scuto postremo dilute aurantiaco; suturis scuto-episcutalibus indistinctis; pedibus compressis, utrinque fere 50, pari postremo gracile; sternis suturis sterno-episternalibus et sulco mediano impressis.

Small, slender, light orange, with two broad, black, dorsal lines passing from head to penultimate segment; head sparsely shortly pilose; antennæ sparsely pilose; labium medianly strongly canaliculate, on each side, with three black maculæ; mandibles within scarcely denticulate; sides maculate with black; last scutum light orange; scuto-episcutal sutures indistinct; feet compressed, about 50 on each side; last pair slender; sterna impressed with the sterno-episternal sutures and a median sulcus.

M. MELANONOTUS, *Wood*, Journ. A. N. S., new series, 1863, vol. v, p. 41.

The two black bands are somewhat irregular and so broad that it would, perhaps, be correct to describe the dorsum as black, with a single median and two longitudinal light stripes. The labium has three black dots on each side, but I suspect that these are not constant. The mandibles have, on their inner edge, the rudiments of a denticule. I have had great difficulty in determining the number of feet, but think that fifty pairs is very near the mark.

There is in the Museum of the Academy a single specimen, collected in Georgia by Dr. John Le Conte. The length is about an inch.

M. LIMATUS.

M. aurantiacus?, venuste politus; capite appendicibusque saturate rubris, segmento cephalico ordinatim punctato, a fronte ordinatim angustato, segmento basali labioque lævibus; antennis sparse longe pilosis; labio valde emarginato, medio leviter canaliculato; mandibulis magnis, pilis longissimis, singula denticulationibus magnis, obtusis, 4; pedibus flavis?, pilosis, utrinque 43—44, postremis valde elongatis; scuto postremo elongato.

Orange, beautifully polished; head and appendages deep red; cephalic segment regularly punctate, regularly narrowed from the front; basal segment and labium smooth; antennæ sparsely long pilose; labium strongly emarginate, medianly lightly canaliculate; mandibles large, with very long hairs, each with four very large, obtuse denticules; feet yellow?, pilose; on each side 43—44; last pair very elongate; last scutum elongate.

M. LIMATUS, *Wood*, Journ. A. N. S., new series, vol. v, 1863, p. 42.

The alcohol in which the specimens were preserved having evaporated, they are in such a condition that I can only guess at the original color of the body and feet. The scuto-episcutal sutures are very distinct, as well as the subsegmental sutures of each fully-formed segment. The sterna are furnished with a median sulcus, deeply marked on the posterior, but obsolescent on the anterior portion of most of them. Length, 2¼ inches.

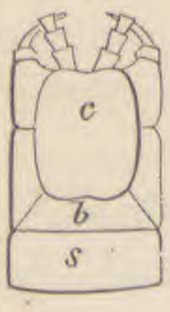
Hab. California.—Smithsonian Collection.

GENUS GEOPHILUS, *Leach*.*

Segmentum cephalicum subquadratum. Segmentum prebasale haud sejunctum, sed basali absolute coalitum. Segmenti basalis margo posticus antico multo longior. Segmentum subbasale sejunctum. Mandibulæ modicæ, interdum denticulatæ. Antennæ capite multo longiores, subapproximatæ, articulis inæqualibus. Labium plerumque emarginatum. (Fig. 19.)

Cephalic segment subquadrate. Prebasal segment not separate, but entirely coalescent with the basal. Posterior margin of the basal segment much longer than the anterior. Subbasal segment separate. Mandibles moderate, sometimes denticulate. Antennæ much longer than the head, subapproximate, their joints unequal. Labium generally emarginate.

Fig. 19.



GEOPHILUS LONGICORNES, *Gervais*, Apt. iv, p. 313.
NECROPHLÆOPHAGUS, *Newport*, Proc. Zool. Soc., 1842, p. 180.
ARTHRONOMALUS, *Newport*, Linn. Trans., xix, p. 430; et Catal. Brit. Mus. Myriap., p. 83; haud Geophilus Newport et imitatores.

Since *Geophilus carpophagus* is the type of the original genus as instituted by Dr. Leach, the name Geophilus must be used for this section, to which *G. carpophagus* belongs, and not for that to which Mr. Newport applies it. Mr. Gervais does not adopt any of these genera, much to my surprise, for they appear to me as clearly and even beautifully defined as almost any that I have ever seen.

G. CEPHALICUS.

G. antice obscure aurantiacus, postice saturate olivaceus; capite magno, latissimo, saturate aurantiaco; segmento cephalico antice haud emarginato, sparse inordinatim punctato, marginibus lateralibus arcuatis; antennis modice longis, valde pilosis; labio sparse inordinatim punctato, medio canaliculato, antice emarginato; pedibus longis, flavescentibus, pilosis, utrinque 48; suturis scuto-episcutalibus conspicuis; superficie ventrali, antice aurantiaca, postice saturate olivacea; sternis suturis sterno-episternalibus et depressione mediana impressis.

Anteriorly obscure orange, posteriorly deep olive; head large, very broad, deep orange; cephalic segment

* Linn. Trans., vol. xi, p. 384.

anteriorly not emarginate, sparsely irregularly punctate; lateral margins arcuate; antennæ rather long, very pilose; labium sparsely irregularly punctate, medianly canaliculate, anteriorly emarginate; feet long, yellowish, pilose, on each side 48; scuto-episcutal sutures conspicuous; ventral surface anteriorly orange, posteriorly deep olive; sterna impressed with sterno-episternal sutures and a median depression.

G. CEPHALICUS, *Wood*, Journ. A. N. S., new series, vol. v, 1863, p. 44.

The body is very wide, as is also the head; the prebasilar segment of the latter is very strongly widened posteriorly. The mandibles have on the inner side one or two excessively minute denticulations. The anterior portion of the body is a dilute orange, but a short distance from the head a dark stripe commences, which, gradually widening, soon involves the whole surface in a very dark olive tint. The scuta are uneven and variously wrinkled. This form differs from the following in having the head very much broader, and the cephalic segment not emarginate anteriorly; the labium much more deeply canaliculate, and the number of segments not so great. Still it is possible that the differences are only sexual, and, having but one specimen of each, I cannot decide this point. The creature was caught near Philadelphia by my friend, Dr. Horn. I append a description of what may be the female of this species.

G. ——— ? G. saturate aurantiacus, robustus, politus; capite parvo; segmento cephalico parvo, antice leviter emarginato, marginibus lateralibus rotundatis; antennis modice longis, proximis pilosis, ultimis fere pubescentibus; mandibulis parvis, indistinctissime tridentatis; labio medio leviter canaliculato, antice leviter emarginato, sparse subprofunde punctato; pedibus brevibus, sparsissime pilosis, utrinque 51.

Deep orange, robust, polished; head small, cephalic segment small, anteriorly lightly emarginate, lateral margins rounded; antennæ rather long, proximally pilose, distally almost pubescent; mandibles small, very indistinctly tridentate; labium medianly lightly canaliculate, anteriorly lightly emarginate, sparsely subprofoundly punctate; feet short, very sparsely pilose, 51 on each side.

The sterno-episternal sutures are well marked, but not as deeply as the scuto-episcutal. The surface of most of the scuta is quite uneven, sometimes almost coarsely rugose. The dorsum has a very indistinct dark median stripe, more apparent on the posterior portion. Length, $1\frac{3}{4}$ inches.

Hab. Cumberland, Md.—Smithsonian Collection.

G. BREVICORNIS.

G. saturate aurantiacus, robustus, venuste politus; capite aurantiaco; segmento cephalico parvo, sparse subprofunde punctato; antennis pilosis, brevibus; mandibulis sparsissime pilosis, indistincte quadridentatis, singula denticulo unico (interdum duobus) modice magno; labio subprofunde punctato, antice emarginato, medio canaliculato; pedibus compressis, utrinque (? in mare) 55, (? in femina.) ?

Deep orange, robust, beautifully polished; head orange; cephalic segment small, sparsely subprofoundly punctate; antennæ short, pilose; mandibles very sparsely pilose, very indistinctly quadridentate, each with a single rather large tooth (sometimes two); labium subprofoundly punctate, anteriorly emarginate, medianly canaliculate; feet compressed, on each side (in male?) 55.

G BREVICORNIS, *Wood*, Journ. A. N. S., 1863, p. 45.

The scuto-episcutal sutures are very distinct, as are also the sterno-episternal. The scuta generally are quite smooth. The body of each of the specimens is subcylindrical. I was at first disposed to consider these as the males of the following species, but it seems most probable that they are distinct. The principal differences are found, first, in the size of the cephalic segment and length of antennæ; second, in the punctations of the head; and finally, in the number of segments and robustness of body. Length, 2 inches.

Hab. Illinois, R. Kennicott; Texas, E. B. Andrews.—Smithsonian Collection.

G. LÆVIS.

G. aurantiacus, modice robustus; linea mediana dorsali, duplici, nigra, passim obsoleta, ad segmentum penultimum ducta; capite modice magno, leviter punctato, segmento basali breve; antennis sparse pilosis; labio saturate aurantiaco, nonnihil convexo, sparse leviter punctato, medio valde canaliculato, antice emarginato; mandibulis haud denticulatis; suturis scuto-episcutalibus modice distinctis; pedibus utrinque 53; superficie ventrali linea mediana unica, obsoleta, nigra; sternis suturis et depressione mediana impressis.

Orange, rather robust; dorsal median line double, black, here and there obsolete, reaching to the penultimate segment; head rather large, lightly punctate; basal segment short; antennæ sparsely pilose; labium deep orange, somewhat convex, sparsely lightly punctate, medianly strongly canaliculate, anteriorly emarginate; mandibles not denticulate; scuto-episcutal sutures rather distinct; feet on each side 53; ventral surface with a single, obsolete, black, median line; sterna impressed with sutures and a median depression.

G. LÆVIS, *Wood*, Journ. A. N. S., new series, vol. v, 1863, p. 44.

The cephalic segment has the sides moderately arched, with the anterior angles very strongly rounded. The dorsal median line is entirely wanting on the anterior portion of the body. The feet generally are without any hairs, but there are a few on some of them. There are two specimens in the Museum of the Academy, collected in Georgia by Dr. J. L. Le Conte.

G. BIPUNCTICEPS.

G. dilute aurantiacus, gracilis, venuste politus; segmento cephalico saturate aurantiaco, magno, antice leviter emarginato, et labio mandibulisque profunde punctatis; antennis modice longis, dense pilosis, antice fere pubescentibus; labio leviter emarginato (interdum obsolete), medio canaliculato; mandibulis magnis, crassis, interdum indistincte quadridentatis, singula denticulo unico (interdum duobus) modice magno; pedibus brevibus, sparsissime pilosis, utrinque (in mare?) 61, (in femina?) 63.

Light orange, slender, beautifully polished; cephalic segment deep orange, large, anteriorly slightly emarginate, together with the labium and mandibles copiously profoundly punctate; antennæ rather long, densely pilose; anteriorly almost pubescent; labium slightly (sometimes obsoletely) emarginate, medianly canaliculate; mandibles large, thick, sometimes indistinctly quadridentate, with a single (sometimes two) rather large tooth; feet short, very sparsely pilose, on each side (in male ?) 61, (in female ?) 63.

G. BIPUNCTICEPS, *Wood*, Journ. A. N. S., 1863, p. 45.

The surface of the head, under a very highly magnifying lens, has the appearance of being very densely and minutely punctate. This is very general in the family, but perhaps is a little marked in this species.

The general arrangement of the larger punctations on the cephalic segment is as follows: On each side of the posterior mesial portion there is a longitudinal series of punctations; on each side of the latter is a broad patch of the same, and anteriorly they are disposed in transverse series. No such method is discoverable in the preceding species. The color in all the specimens I have seen is somewhat lighter, and the body less robust, and perhaps more uniform than in *G. brevicornis*. The labium is of the same shade as the cephalic segment, but the basilar and subbasilar are colored like the body. The dorsum has occasionally an indistinct dark median stripe. The labial sulcus is more distinct anteriorly, but is sometimes quite obsolete. The scuto-episcutal and sterno-episternal sutures are very distinct. The sterna have a median groove. I have seen an individual, belonging to the collection of the Museum of Comparative Zoology, which has 65 pairs of feet on each side, but yet in other respects agrees entirely with the others.

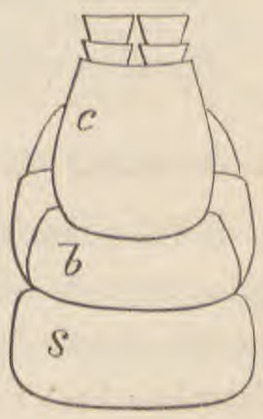
Hab. S. Illinois, R. Kennicott; Sonora, T. D. Graham.—Smithsonian Collection.

GENUS STRIGAMIA, *Gray*.

Antennæ approximatæ. Segmentum cephalicum parvum (Fig. 20 *c*), breve, plerumque subtriangulare, antice angustatum. Corpus depressum, antice attenuatum. Segmenta pedesque numerosæ.

Antennæ approximate. Cephalic segment small, short, generally subtriangular, anteriorly narrowed. Body depressed, anteriorly attenuate. Segments and feet numerous.

Fig. 20.



GEOPHILUS, *Leach*, partim.

STRIGAMIA, *Gray*, partim.

GEOPHILUS, *Newport*, et imitatores.

As I have before shown, the type of Leach's genus Geophilus belongs to the section Arthronomalus of Newport; and Arthronomalus must be replaced by Geophilus, and a new name given to Geophilus, Newport.

S. BOTHRIOPUS.

S. læte rubens, robusta; segmento cephalico sparse punctato, piloso; antennis pilosis, modice longis, haud acuminatis; mandibulis pilosis, intus dente magno, conico, acuto armatis; labio piloso, antice profunde emarginato, medio canaliculato; scutis pilosis, latis, brevibus, sine suturis; pedibus plerumque flavis, dense pilosis, utrinque 50; paris postremi coxis magnis et foveis minutis multis impressis; sternis suturis sterno-episternalibus et sulco medio obsoleto signatis.

Bright red, robust; cephalic segment sparsely punctate, pilose; antennæ pilose, moderately long, not acuminate; mandibles pilose, within armed with a large, conical, acute tooth; labium pilose, anteriorly profoundly emarginate, medianly canaliculate; scuta pilose, broad, short, without sutures; feet generally yellow, densely pilose, 50 on each side; last pair with the coxæ large, and impressed with many minute pits; sterna marked with sterno-episternal sutures and an obsolete median sulcus.

S. BOTHRIOPUS, *Wood*, Journ. A. N. S., new series, vol. v, 1863, p. 46.

The body is widest in the middle, but is much narrower at the anterior than at the posterior extremity. The last pair of feet are scarcely longer than the preceding. This species closely resembles *G. rubens*, Say, and may possibly prove identical with it, as the descriptions of that form are as usual quite meagre. Length, 1 inch.

Hab. Pennsylvania.

S. RUBENS.

S. "saturate aurantiaca; linea mediana duplici nigra e segmento corporis primo ad penultimum ducta, segmento cephalico subcordato, antennis pilosis, labio mandibulisque lævigatis punctis raris, mandibulis nigris, pedum paribus 50. Long. unc. 1¼."

Deep orange, with a black double line passing from the first segment of the body to the penultimate; cephalic segment subcordate; antennæ pilose; labium and mandibles smooth, rarely punctate; mandibles black; pairs of feet 50. Length 1¼ inches.

GEOPHILUS RUBENS, *Say*, Journ. Acad. Nat. Sci., Philada., 1st series, vol. ii; Œuvr. Entom. i, p. 25.
" " *Gervais*, in Ann. Sci. Nat., 1837, p. 52; Apt. iv, p. 320.
" " *Lucas*, Hist. Nat. Anim. Art., p. 549.
" " *Newport*, Ann. and Mag. Nat. Hist., xiii, p. 101; Linn. Trans., xix, p. 435; Catal. Brit. Mus. Myriapoda, p. 87.

"*Hab.* In America Boreali."

Species mihi ignota.

S. FULVA.

S. fulvo-aurantiaca, polita; corpore antice attenuato; capite parvo; segmento cephalico subtriangulare, impunctato; antennis modice longis, filiformibus, haud acuminatis, sparse pilosis, articulis obconicis; mandibulis brevibus, crassis, singula denticulo modice magno conico; labio breve, antice medio valde emarginato, impunctato; scutis interdum linea media obsoletissima; pedibus modice longis, pilosis, gracilibus, cylindricis, utrinque 47; pari pos-

tremo (in mare ?) robusto, breve acuminato, articulis obconicis; sternis suturis sterno-episternalibus et sulco mediano lato impressis.

Yellowish orange, polished; body anteriorly attenuate; head small; cephalic segment subtriangular, impunctate; antennæ moderately long, filiform, not acuminate, sparsely pilose, joints obconic; mandibles short, thick, each with a rather large, conical denticule; labium short; anteriorly very emarginate, impunctate; scuta sometimes with a very obsolete median line; feet rather long, pilose, slender, cylindrical, on each side 47; last pair (in male ?) robust, shortly acuminate, articles obconic; sterna impressed with a broad, median sulcus and sterno-episternal sutures.

STRIGAMIA FULVA, *Sayer*, Proc. A. N. S., vol. viii, p. 109.
" " *Wood*, Journ. A. N. S., new series, 1863, vol. v, p. 47.

The color of this graceful little animal is an orange, approaching somewhat to fulvous. The antennæ are very thread-like. Some of the specimens have the last pair of feet very robust, with obconic joints. In others they are filiform and slender. The former are probably the males, the latter the females. I have, however, never been able to entirely satisfy myself as to this, owing to the great difficulty of dissection. The median linear depressions in the sterna are often dilated in their centre.

Hab. Illinois, Pennsylvania, &c.

S. BIDENS.

S. aurantiaca, venuste polita; segmento cephalico triangulare, antice truncato, sparse late punctato, margine antico postico nonnihil latiore; antennis brevibus, filiformibus, articulis obconicis; labio sparse late punctato, sulco obsoleto, margine antico denticulis duobus obsoletis obtusis armato; mandibulis intus minute unidenticulatis; suturis scuto-episcutalibus nullis; pedibus utrinque 76, cylindricis, paris postremi coxis magnis, foveis signatis; sternis suturis sterno-episternalibus et sulco mediano impressis; squama preanali convexa.

Orange, beautifully polished; cephalic segment triangular, anteriorly truncate, sparsely broadly punctate; the anterior margin somewhat broader than the posterior; antennæ short, filiform, their joints obconical; labium sparsely broadly punctate, sulcus obsolete, anterior margin armed sometimes with two obtuse, obsolete denticules; mandibles within minutely unidenticulate; scuto-episcutal sutures absent; feet on each side 76, cylindrical; coxæ of last pair large and marked with little pits; sterna impressed with sterno-episternal sutures and a median sulcus; preanal scale convex.

S. BIDENS, *Wood*, Journ. A. N. S., new series, 1863, vol. v, p. 47.

The coxæ of the last pair of feet are very large. Their inferior surface is convex, and indented with from twenty to thirty small, round pits, irregularly arranged in rows. The remainder of the feet are, in our specimen, slender. I presume that the above character is persistent in both sexes, but cannot be certain on this point. There is a single specimen in the Museum of the Academy, labelled as having been found near Philadelphia by Joseph Leidy, M.D. I have never met with it whilst collecting. The length is about an inch and a half.

S. WHITEI.

S. "capite aurantiaco, corpore flavo-virente, segmento cephalico brevi subcordato, antennis nudis, moniliformibus, labio leviter longitudinaliter cristato, utrinque obliqué sulcato, pedum paribus 74. Long. unc. 1¼."

Head orange; body yellowish green. Cephalic segment short, subcordate; antennæ bare, moniliform; labium lightly longitudinally crested; on each side obliquely sulcate; pairs of feet 74. Length, 1¼ inches.

GEOPHILUS WHITEI, *Newport*, Linn. Trans., xix, p. 436.
" " *Gervais*, Apteres, iv, p. 321.

"*Hab.* In America Boreali."

Species mihi ignota.

G. ATTENUATUS, *Say*, Journ. Acad. Nat. Sci., 1st series, vol. ii, p. 114.

I have not been able to learn anything as to what species Mr. Say referred in his description, which throws no light on the subject; possibly it belonged to the genus Mecistocephalus.

S. WALKERI, sp. nov.

S. aurantiaca; capite parvo, sparse leviter punctato; mandibulis magnis, singula dente magno unico armata; scutis sine suturis; suturis sterno-episternalibus distinctis; pedibus utrinque 64; paris postremi coxis magnis, foveis minutis multis impressis.

Orange, head small, sparsely lightly punctate; mandibles large, each armed with a single large tooth; scuta without sutures; sterno-episternal sutures distinct; feet on each side 64; coxæ of the last pair large, impressed with many minute pits.

The head is small and of a more reddish tint than the body. The antennæ are of medium length, filiform, not at all clavate, and very sparsely minutely pilose. The body narrows much more gradually and somewhat more decidedly anteriorly than posteriorly. The last pair of legs in the single specimen are small and slender; their coxæ are large and pitted. Many of the sterna have three more or less obsolete depressions on their anterior portion, and two larger ones on their posterior; on some of them there is a longitudinal mesial groove. I would dedicate this species to my friend and student, Robert J. Walker, whose untiring energy in collecting has aided me so much in the preparation of this monograph.

Hab. Western Pennsylvania.—R. J. Walker.—Smithsonian Collection.

S. LÆVIPES.

S. aurantiaca, robusta; capite modice magno, sparse piloso; segmento basilari margine antico postico nonnihil

latiore; mandibulis magnis, singula intus denticulo magno acuto armata; dente mandibulari, gracile, longo; scutis latis, brevibus, suturis scuto-episcutalibus nullis; pedibus modice longis, utrinque 69, pari postremo—(in mare?) longo, valde incrassato, illico acuminato, articulis obconicis—(in femina?), parvo, gracile, articulis subcylindricis; suturis sterno-episternalibus distinctis; squama preanali postice valde angustata.

Orange, robust; head rather large, sparsely pilose; anterior margin of basilar segment somewhat greater than posterior; mandibles large,—each armed on inside with a large, acute, denticule; mandibular tooth, slender, long; scuta broad, short; scuto-episcutal sutures absent; feet rather long, on each side 69; last pair—(in male?) long, very much thickened, rapidly acuminate, articles obconic—(in female?), small, slender, articles subcylindrical; sterno-episternal sutures distinct; preanal scale posteriorly very much narrowed.

S. LÆVIPES, *Wood*, Journ. A. N. S., new series, vol. v, 1863, p. 48.

One of the specimens has the last pair of legs very thick and long and vertically compressed. They are composed of eight joints, all of which are obconic except the last, which is very short and rapidly acuminate. This individual is probably the male. The other, the female, has the hindmost legs very slender, with the coxal joint proportionally very much larger than in the male.

Hab. Georgia.—Museum of Academy; Dr. J. L. Le Conte.

S. TÆNIOPSIS.

S. dilute fulva; corpore valde depresso, modice lato, antice leviter angustato; capite magno; segmento cephalico subtriangulare; antennis brevibus, moniliformibus, postice leviter depressis, crassis, antice cylindricis, haud acuminatis, pilis brevissimis mollibus paucis; labio breve, lato, antice obsolete bidentato, sulco mediano leviter impresso; mandibulis crassis; scutis brevissimis, sine suturis sed interdum linea mediana obscura; sternis brevissimis, singulo depressione submediana ovata in corpore antico conspicuissima; pedibus brevibus, crassis, cylindricis, haud pilosis, utrinque 141, pari postremo (in femina?) gracile, breve. Long. unc. $4\frac{3}{4}$.

Light yellow; body very depressed, rather broad, anteriorly slightly narrowed; head large; cephalic segment subtriangular; antennæ short, moniliform, posteriorly slightly depressed, thick, anteriorly cylindrical, not acuminate, with a few soft, very short hairs; labium short, broad, anteriorly obsoletely bidentate, impressed with a slightly pronounced median sulcus; mandibles thick; scuta very short, without sutures, but with sometimes an obscure median line; sterna very short, each with a single submedian ovate depression, most conspicuous on the anterior portion of the body; feet short, thick, cylindrical, not pilose, on each side 141, last pair (in female?) slender, short. Length, $4\frac{3}{4}$ inches.

S. TÆNIOPSIS, *Wood*, Journ. A. N. S., new series, vol. v, 1863, p. 48.

In the single specimen the color is very light, but originally may possibly have been an orange. The body is almost destitute of polish. The epimeral plates are very large. I am indebted to Dr. J. L. Le Conte for the specimen, which he captured in the mountains of Georgia.

S. MACULATICEPS.

S. sordide aurantiaca, polita; corpore robusto, subsemicylindrico, antice modice attenuato; capite modice parvo, obscure saturate rubro, minute albomaculato, in lateribus sparse piloso; antennis longis, leviter pubescentibus, haud acuminatis; mandibulis crassis, obscure quadridentatis, pilis paucis; denticulo antico utrinque magno, conico; labio impunctato, antice vix emarginato, medio canaliculato; pedibus modice longis, gracilibus, subcompressis, utrinque 77, et superficie ventrali sordide flavis; scutis lævibus sine suturis; sternis lævibus, suturis sterno-episternalibus valde impressis et plerumque postice depressionum subovatarum transversarum pari; pedibus postremis ("stylis analibus") (in mare solum ?) robustissimis, supra subcomplanatis, subtus convexis, acuminatis.

Dirty orange, polished; body robust, subsemicylindrical, anteriorly moderately attenuate; head rather small, obscurely deep red, minutely spotted with white, sparsely pilose on the sides; antennæ long, lightly pubescent, not acuminate; mandibles thick, obscurely quadridentate, with a few hairs; anterior denticule on each side large, conical; labium impunctate, anteriorly scarcely emarginate, medianly canaliculate; feet rather long, slender, subcompressed, on each side 77, together with the ventral surface dirty yellow; scuta smooth, without sutures; sterna smooth, strongly impressed with the sterno-episternal sutures, and generally with a pair of irregularly ovate, transverse depressions; last pair of feet ("anal styles") (in male only?) very robust, above subcomplanate, below convex, acuminate.

S. MACULATICEPS, *Wood*, Journ. A. N. S., new series, vol. v, 1863, p. 48.

The cephalic segment is slightly narrowed anteriorly, and the upper surface of the whole head is marked with very small whitish dots. The anterior and posterior extremities of the body are perhaps a little darker in color than the intervening portion. The inferior aspect of the head is of the same color as the superior, contrasting with the under surface of the body. Near the posterior border of each sterna there is a pair of subequal oval transverse depressions. The legs are almost destitute of hair, having occasionally, however, a few very short ones. Length, 2½ inches.

Hab. Upper Colorado. H. B. Mollhausen.—Smithsonian Collection.

S. LATICEPS.

S. dilute aurantiaca; capite magno, impunctato; segmento cephalico lato, breve, transverso, quinqueangulato, segmentis basali subbasalique marginibus curvatis et angulis anticis prolongatis; antennis brevibus, crassis, cylindricis, antice pubescentibus; labio breve, nonnihil convexo, haud canaliculato; mandibulis parvis, singula intus denticulo obtuso indistincto; pedibus subcompressis, gracilibus, utrinque 81, pari postremo (in mare solum ?) nonnihil crasso, cylindrico, haud acuminato, coxis magnis; sternis depressione lineari-ovata transversa et suturis sterno-episternalibus signatis; squama preanali valde canaliculata, postice valde emarginata, angulis posticis subacutis.

Light orange; head large, impunctate; cephalic segment broad, short, transverse, quinqueangulate; basal and subbasal segments with their margins curved and anterior angles prolonged; antennæ short, thick, cylindrical, anteriorly pubescent; labium short, somewhat convex, not canaliculate; mandibles small, each with an indistinct obtuse tooth on inner surface; feet subcompressed, slender, 81 on each side; last pair (in male alone?) somewhat thickened, cylindrical, not acuminate, with large coxæ; sterna marked with a transverse linear-ovate depression

and sterno-episternal sutures; preanal scale deeply canaliculate, posteriorly strongly emarginate, posterior angles subacute. Length, 3 inches.

S. LATICEPS, *Wood*, Journ. A. N. S., new series, 1863, vol. v, p. 49.

The anterior of the two scuta covering each segment is very distinct from the other, and is much wider at its posterior than at its anterior margin. The posterior has its lateral margins arcuate but not elevated. The scuto-episcutal sutures are very distinct. Posteriorly there is an obsolete dark median dorsal line. Length, 3 inches.

Hab. Texas.—Museum of Comparative Zoology; George Stolley, Esq.

S. CEPHALICA.

S. sordide dilute brunnea, superficie dorsali lineis pullis duabus, obsoletis; corpore antice leviter sed postice illico valdeque angustato; capite magno; segmento cephalico subtriangulare, impunctato, basali postice leviter dilatato; antennis brevissimis, latis, depressis, haud pilosis, articulis brevissimis, nonnihil quadratis; labio impunctato, medio canaliculato, antice leviter emarginato; mandibulis crassis, haud denticulatis; suturis scuto-episcutalibus nonnihil obsoletis; pedibus gracilibus, modice brevibus, haud pilosis, utrinque 75, pari postremo (in femina solum ?) parvo, gracile; sternis suturis sterno-episternalibus et sulco mediano impressis.

Dirty light brown; dorsal surface with two obsolete, blackish lines; body anterior slightly, but posteriorly quickly and strongly narrowed; head large; cephalic segment subtriangular, impunctate; basal posteriorly slightly dilated; antennæ very short, broad, depressed, not pilose, with very short, somewhat quadrate joints; labium impunctate, medianly canaliculate, anteriorly lightly emarginate; mandibles thick, not denticulate; scuto-episcutal sutures somewhat obsolete; feet slender, rather short, not pilose, on each side 75; last pair (in female only ?) small, slender; sterna impressed with sterno-episternal sutures and a median sulcus.

S. CEPHALICA, *Wood*, Journ. A. N. S., new series, 1863, vol. v, p. 49.

The two dark lines on the dorsum are very obscure, and are evanescent anteriorly. The cephalic segment is quite acute anteriorly. The legs are rather lighter in color than the body, and are shorter than in the preceding species. Length, 2¼ inches.

Hab. California.

S. PARVICEPS.

S. saturate aurantiaca, polita; corpore antice valde sed postice leviter angustato; capite parvo, segmento cephalico suborbiculare, impunctato; antennis modice longis, filiformibus, haud acuminatis, sparse pilosis, articulis nonnihil obconicis; mandibulis crassis, sparse breve pilosis, obscure tridenticulatis, denticulo antico utrinque magno conico acuto; labio lato, breve, impunctato, vix emarginato, sulco mediano obscure impresso; scutis sine suturis; pedibus modice longis, gracilibus, pilis brevibus paucis, et superficie ventrali sordide aurantiacis, utrinque 71, pari postremo (in femina solum ?) parvo, gracile; sternis suturis sterno-episternalibus et sulco mediano impressis.

Deep orange, polished; body anteriorly strongly, but posteriorly slightly narrowed; head small; cephalic segment suborbicular, impunctate; antennæ rather long, filiform, not acuminate, sparsely pilose, articles somewhat obconic; mandibles thick, sparsely shortly pilose, obscurely tridenticulate; anterior denticule on each side, large, conical acute; labium broad, short, impunctate, scarcely emarginate, impressed with an obscure median sulcus; scuta without sutures; feet rather long, slender, with a few short hairs, together with the ventral surface dirty orange, on each side 71; last pair (in female only?) small, slender; sterna impressed with the sterno-episternal sutures and a median sulcus.

S. PARVICEPS, *Wood*, Journ. A. N. S., new series, vol. v, 1863, p. 49.

In the only specimen that I have seen the mandibles are perfect, with the exception that they lack the mandibular tooth, probably the result of an accident; but it is rather curious that both should be lost and the remainder of mandibles be uninjured. The head appears to be destitute of punctations. Length, $2\frac{1}{4}$ inches.

Hab. California.—Smithsonian Collection.

S. EPILEPTICA.

S. polita; corpore antice valde sed postice modice angustato, supra saturate sed subtus dilute aurantiaco; capite parvo; segmento cephalico suborbiculare, albomaculato; segmento basali subbasali longiore; antennis longis, filiformibus, haud acuminatis, partim pubescentibus, articulis nonnihil obconicis; mandibulis crassis, distincte tridenticulatis, denticulo antico magno, conico, acuto; labio convexo, copiose minute albomaculato, antice leviter emarginato, sulco mediano impresso; scutis longis, latis, sine suturis; pedibus gracilibus, modice longis, dilute aurantiacis, utrinque 81; pari postremo (in femina solum?) parvo, gracile, haud antenniforme; sternis suturis sterno-episternalibus et sulco mediano impressis. (Figs. 21, 22.)

Fig. 21.

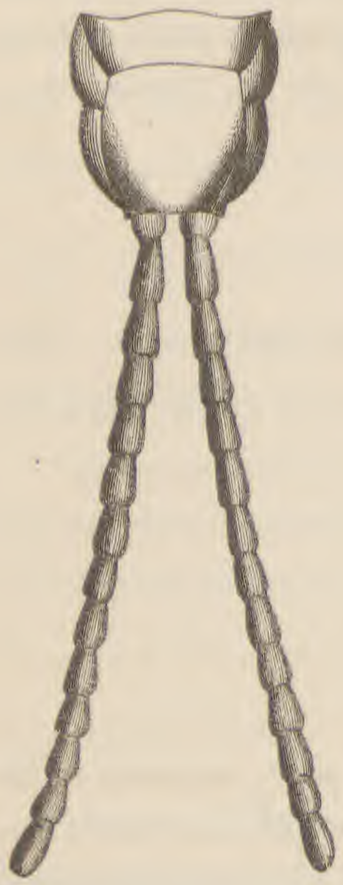
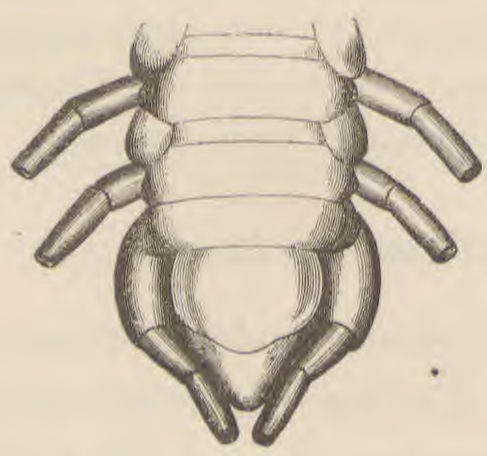


Fig. 22.



Polished; body anteriorly strongly, but posteriorly moderately narrowed. Above deep, below dilute orange; cephalic segment suborbicular, sparsely minutely spotted with white; basal segment longer than the subbasal; antennæ long, filiform, not acuminate, partly pubescent; joints somewhat obconic; mandibles thick, distinctly tridenticulate; anterior denticule large, conical, acute; labium convex, copiously minutely spotted with white; anteriorly somewhat emarginate, impressed with a median sulcus; scuta long, broad, without sutures; feet slender, rather long, light orange, on each side 81; last pair (in female only?) small, slender, not antenniform; sterna impressed with sterno-episternal sutures and a median sulcus.

S. EPILEPTICA, *Wood*, Journ. A. N. S., new series, vol. v, 1863, p. 49.

This is much the largest Geophilid as yet found within our limits. The greatest breadth of the scuta is about two lines. The white dots on its head are very minute, resembling punctations. Length, 5½ inches.

Hab. Oregon. Neighborhood of Puget's Sound; Dr. Kennerly.—Smithsonian Collection.

S. CHIONOPHILA.

S. aurantiaca, gracilis, parva, venuste polita; segmento cephalico fere subquadrato, postice medio canaliculato; antennis pilosis, haud acuminatis, articulis (ultimo excepto) obconicis; mandibulis dente modico in margine interno armatis; suturis scuto-episcutalibus interdum obsoletis sed plerumque distinctis; pedibus pilosis, utrinque 43; pari postremo (in femina solum?) gracile, parvo; sternis vel canaliculatis vel depressione subcirculare notatis et suturis sterno-episternalibus valde impressis.

Orange, slender, small, beautifully polished; cephalic segment almost subquadrate, posteriorly medianly canaliculate; antennæ pilose, not acuminate; their joints (the distal one excepted) obconic; mandibles armed with a moderate denticule upon their internal margin; scuto-episcutal sutures sometimes obsolete, but generally distinct; feet pilose, on each side 43; last pair (in female alone?) slender, small; sterna either canaliculate or marked with a subcircular depression, and impressed with the sterno-episternal sutures.

S. CHIONOPHILA, *Wood*, Journ. A. N. S., new series, vol. v, 1863, p. 50.

The distal joint of the filiform antennæ is large and cylindrical, causing them to appear somewhat clavate. This species is a very interesting one, from the fact of its inhabiting a region so near the Arctic circle. Its diminutiveness shows that the Myriapoda form no exception to the general decrease in size observable among the lower animals as we leave the Equator. Length, ¾ inch.

Hab. Fort Simpson, Red River of the North; R. Kennicott.—Smithsonian Collection.

ORD. II. DIPLOPODA.

Corporis segmenta, singulum pedum paribus duobus instructum.

Segments of the body numerous; each furnished with two pairs of feet.

The body among the Diplopoda is more or less cylindrical, not flat and parallelopipedal, as in the Chilopoda. Neither of the subsegments composing a segment is atrophied, nor are their appendages; consequently each segment is provided with two pairs of legs. These have coxæ, femora, tibial, tarsal, and metatarsal joints. The coxæ of the last pair are never hypertrophied, as in the first order. The organs of special sense are not well developed. The eyes are frequently altogether absent; when they do exist, they are generally numerous, scarcely at all elevated above the surface, and collected in patches near

the base of the antennæ. The latter are generally short, thick, and clumsy, indeed in many genera they seem almost incapable of fulfilling any physiological function.

The external organs of nutrition are arranged in accordance with two types or plans. The one is adapted for feeding upon decaying vegetable matter, the other for the imbibition of liquid or semi-liquid food. In each there is so much coalescing and atrophying of parts that it is impossible to trace in the adult their homologies.

Iulus marginatus may be taken as an example of the first type. On examining the mouth of this myriapod, it will be found that the anterior or upper boundary is formed by the thin edge of the head; whilst the lower is the edge of a flat plate (Fig. 23), which forms the lower surface of the buccal cavity and throat. Working between this plate and the head are the jaws. These are very massive, and appear to consist of three joints; the two proximal of these are firmly connected, almost coalescent, whilst the distal is united to them by a membranous suture. The basal or proximal part articulates with the head just beneath and posterior to the ocelli, and is so placed as to have its long axis nearly parallel with that of the body. Near to its distal extremity the mandibles curve abruptly at right angles, so that the distal joints (Fig. 24) present two opposing surfaces or edges. These are firm, hard, and more or less thin and acute. They are armed with more or less strongly pronounced conical elevations or teeth, and seem well adapted for breaking and cutting off substances.

Fig. 23.



Fig. 24.



The floor of the mouth and under surface of the head is formed by a single thin flat plate (Fig. 23) composed of several closely united pieces. The outer anterior part is formed on each side by a triangular piece, from which project a pair of short, blunt processes.

In the *sugentia*, or second division, the parts about the mouth are all consolidated into a tube-like projection or beak of greater or lesser length.

Sub Ord. CHILOGNATHA.

Caput magnum, nonnihil cuneiforme. Mandibula maxima.

Head large, somewhat cuneiform. Mandibles very large.

The American species of this suborder, which have come under the author's notice, are in this paper arranged in three families, the Iulidæ, Lysiopetalidæ, and Polydesmidæ. A fourth, the Polyxenidæ, is said to be represented. Of these, the first two constitute the Iulidæ of Newport, they themselves ranking as subfamilies in the classification of that authority. If any force is to be given to the characters employed by Mr. Gray, his

family Craspedosomidæ includes both the subfamilies Lysiopetalidæ and Craspedosomidæ of Newport, although these are placed by the latter in different families. Whether these two groups belong together or not I cannot say, since I have never seen a specimen of the Craspedosomidæ of Newport. The Lysiopetalidæ, as defined in this memoir, includes that of Mr. Newport, but whether it reaches still further I cannot certainly say, on account of the differences in the characters used. The distinguishing mark of the Polydesmidæ is commonly supposed to be the possession of lateral lamina or side plates. Now, on glancing over a selected series of specimens, it will be seen that there is a regular gradation in size, from the largest lateral lamina to those which are merely rudimentary. Further, in some species of Lysiopetalidæ, the whole surface is strongly keeled, and the keel corresponding in position to the lateral lamina is so enlarged as to equal in size the smaller lateral lamina. The groups thus coming, as regards this character, in contact, or at least very close proximity.

If a segment of a species of each of the three groups is examined, it will be found that fixed characters can be drawn from the varying development of the sterna of the subsegments. In the Polydesmidæ both of the sterna are thoroughly developed, so that the segment constitutes a perfect ring. In the Julidæ the sterna of the posterior subsegments are atrophied, so that each segment is emarginate posteriorly. In the Craspedosomidæ both sterna are reduced to their minimum, and not consolidated with the scuta, so that the ring is left altogether incomplete. I have placed the Polydesmidæ below instead of above the other families, because they have both the organs of special sense and the locomotory apparatus least developed.

Ord. LYSIOPETALIDÆ.

Sterna minima, cum scutis haud conjuncta.

Sterna very small, not conjoined with the scuta.

There is much obscurity hanging around the genera of this family; so much that, in the absence of known representatives and types, it is impossible to clear it up.

Genera, with precisely opposite characters, families widely separated, have been tortured out of what claims to be one species.

In "Europe Méridionale," M. Risso described a genus under the name of Calipus, the type of which is a European species, which, M. Gervais says, belongs to the genus Lysiopetalum. Risso's generic characters apply nearly equally well to any Chilognath. Yet, if Gervais is right, his name should have the preference. In Recueil (p. 42), M. Brandt indicated the genus Lysiopetalum, and afterwards (p. 90), the genus Spirostrephon. The description of the former is mostly made up of what I consider family cha-

racters; that of the latter is founded on an entirely distinct set—is, in truth, a description comparative not with the allied genera, but with those of the Iulidæ. In "Ann. and Mag. Nat. Hist.," Mr. Newport described a genus Platops. His description has apparently not the slightest relation to that of M. Brandt; but Platops seems to be the same as Spirostrephon, from the fact that the type of the latter is one of Mr. Newport's new species. Mr. Gervais unites Lysiopetalum and Platops together, whether correctly or not I cannot say, not having seen enough specimens. Although with my present light it appears probable that they are one, yet, out of deference to the opinions of Messrs. Brandt and Newport, they are in this paper considered distinct.

Genus SPIROSTREPHON.*

S. LACTARIUS.

S. brunneus, lineis rufo-brunneis tribus ornatus; scutis valde et arcte carinatis; segmentis 59.

Brown, ornamented with three reddish brown lines; scuta closely and strongly keeled; segments 59.

Var. Nigro brunneus, haud lineatus.

Var. Blackish brown, not lineate.

JULUS LACTARIUS, *Say*, Journ. A. N. S., 1st series, vol. ii, p. 104.
PLATOPS LINEATUS, *Newport*, Ann. and Mag. Nat. Hist., vol. xiii, p. 267.
SPIROSTREPHON LACTARIUS, *Brandt*, Recueil, p. 90.
LYSIOPETALUM LINEATUM, *Gervais*, Apteres, vol. iv, p. 133.
CAMBALA LACTARIUS, " " " p. 134; Exped. L'Amer. du Sud (Castelneau), Myriap., p. 17.
REASIA SPINOSA, *Sæger*, Proc. A. N. S., 1856, p. 109.
"REANA CHINOSA, *Sæger*," *Gervais*, Exped. L'Amer. du Sud (Castelneau), Myriap., p. 14.

Haud. "JULUS LACTARIUS, *Say*;" *Gray* et *Newport*.
CAMBALA LACTARIUS, *Gray*, Griff., Animal Kingdom Ins., pl. 135, fig. 2.
" " *Newport*, Ann. and Mag. Nat. Hist., vol. xiii, p. 266.

The color in this species varies from a very light to a very dark brown. The ornamental lines are generally very distinct, but may be entirely absent, especially in those specimens which have a blackish tint.

The head is somewhat emarginate in its superior posterior border. The vertex is dark colored, convex, medianly obsoletely canaliculate, and copiously minutely distinctly punctate. The anterior aspect is rather narrow, lighter colored, and provided with numerous

* Brandt.

short hairs. Its border is rather deeply emarginate. The eyes are in triangular patches, and are quite prominent. The antennæ are rather long, filiform, pilose, and not at all clavate. The first scutum has its transverse diameter scarcely equal to that of the head. The anterior portion of its surface is smooth, the posterior strongly carinate. The surface of the other scuta is divisible into three regions. The anterior of these is the broader, and is strongly and closely keeled. The middle is the least in size, and is ornamented with closely set small keels, entirely evanescent on the sides. The posterior is not at all keeled, but is chased with curved, impressed lines. The keels at the position of the lateral pores are much enlarged and thickened. On the surface above them there are about seventeen keels to a segment. The last scutum is not at all pointed. The posterior portion of the body is more or less pilose. The preanal scale is broadly triangular.

The female appendages appear to consist of a pair of somewhat conical flattened bodies, with rounded summits, surmounted by a curved, rather thick, process, which springs from the base. The male appendages (Fig. 25) consist of two basal, irregular pieces, closely conjoined, and two processes arising from each of them. The smaller of these is short, broad, rather straight and acute at its end. The larger is composed of two parts. The shaft is irregular and proximally curved at right angles to itself; from its distal end proceeds at a sharp angle a curiously curved, somewhat spoon-shaped, portion; from near the point of junction of these arise a pair of subcylindrical, nearly parallel, curved processes. One of these is frequently distally bifid.

Fig. 25.



Mr. Say, in his description of Iulus lactarius, uses the following expression: "Eyes *triangular*, granulated, deep black." In the Annals and Magazine Nat. Hist., vol. xiii, p. 266, Mr. Newport states that there were in the British Museum the original specimens sent by Mr. Say to Dr. Leach as Iulus lactarius, and that their eyes were arranged in linear patches. He there indicates a new genus, under the name of *Cambala*, with Iulus lactarius, Say, for its type, and characterizes it by its *linear* eye-patches. On the other hand, Mr. Brandt (Recueil) identifies certain specimens with triangular eye-patches in the Museum at Berlin as I. lactarius of Say. M. Gervais, reviewing this, concludes that Mr. Newport must have been mistaken, that his Cambala lactarius is not I. lactarius of Say. I have seen very numerous specimens from different localities agreeing in all respects with Mr. Say's description, but never one with linear eye-patches. Again, I find that Mr. Newport's description of Platops lineatus coincides with the specimens which I identify as I. lactarius of Say. Now, can there be any doubt that, through the carelessness of some one, the label had been transferred to the bottle of specimens which Mr. Newport studied, and that really his P. lineatus was founded on the type specimens of Say's spe-

cies? I have examined the types of Reasia spinosa, and there can be no doubt as to its identity.

I have seen a single specimen, a female, labelled as coming from New Grenada, which apparently belongs to this species.

Hab. Eastern United States.

S. CÆSIOANNULATUS.

S. brunneus, cæsioannulatus; segmentis 32, singulo serie punctorum distantum ornato.

S. brown, annulate with gray; segments 32, each with a series of distant puncta.

The general color of this curious Myriapod is light brown, but on each scutum is a broad gray annulus. The anterior surface of the head is hollowed out at the position of the ocelli; in front of these the sides are straight and converging. The inferior margin is rather deeply emarginate. The basal portion of the mandibles on each side project, so that if a vertical section of the head through the middle were taken it would be an oval with its greater diameter transverse. The eyes are in strictly triangular patches, with remarkably straight sides. The scuta are so deeply canaliculate along their dorsal centre as to be almost divided into two parts. The dorsum is not perfectly rounded, but there is somewhat of a ridge or angle in the centre. Each scutum is furnished with a regular series of distant large puncta, or perhaps more properly, pores. Three cylindrical, transparent spinules, project from the posterior border of the last scutum. There is a single specimen, a female, in the Smithsonian Museum,—it measures about an inch in length, and was found by Mr. Robert J. Walker in Alleghany County, Pennsylvania. This species ought perhaps to be the type of a new genus; but, as I am unable to make out the generic characters in this family, it seems preferable to retain it in this for the present.

FAM. II. IULIDÆ.

Subsegmentorum posticorum sterna subnulla, subsegmentorum anticorum sterna modica et illa et haec cum scutis arcte conjuncta. Scuta laminis lateralibus haud instructa.

Sterna of the posterior subsegments almost absent, of the anterior moderate, both closely conjoined with the scuta. Scuta not furnished with lateral lamina.

The head in this family is moderately large, and generally has the organs of special sense well developed. The eyes are present in all our American species, arranged in variously shaped patches, near to the base of the antennæ. The latter are sometimes

long and filiform; but in the genus Spirobolus they are generally short and massive. The body is cylindrical and composed of very numerous segments, which are more or less imbricated. The line of conjunction of the two subsegments is almost, if not quite, always well marked. The organization of this family is more fitted for activity and their habits less sluggish than in the Polydesmidæ, although less so than in the Spirostrephonidæ. The coloration varies, some species being ornamented with annuli, others with stripes. The only surface markings, in our American species at least, consist of longitudinal channels, or flutings and punctations.

The American species are comprised in two genera, Iulus, Spirobolus. Some authors recognize a third genus, Uncigera, founded on the presence of a mucro or point on the posterior scutum. Now a suite of specimens shows this at once to be such a gradually developed character that it is almost impossible to say where the last scutum is simply acuminate, and where it is slightly mucronate. Besides, species which appear in every other respect to be very closely allied would be thrown into different genera, were this Uncigera to be recognized as such.

The specfic characters are drawn: 1. From the number of segments composing the body. 2. From the coloration and surface markings. 3. From the last scutum. 4. From the genital appendages, besides other minor points, such as differences in the antennæ, shape of the head, &c.

The number of segments is apparently confined within a small limit in the adult of each species; but in applying this character, it must be remembered, that the young have less than the normal number. Where there is anything peculiar in the pattern of coloration, it appears to be persistent in the species. Surface markings more generally characterize small groups than individual species, yet are sometimes available even in closely allied forms. The possession of a mucro characterizes groups; whilst its size and its shape are often specific. As in all the other Diplopoda, each species has a peculiar and persistent form of the Genitalia, more marked in the male than in the female. Indeed a certain type of arrangement seems in this group to characterize a genus.

Genus IULUS.

Scutum primum magnum, lateribus in femina nonnihil productis. Scuti secundi latera haud producta.

Sides of the first scutum somewhat produced in the female. Sides of the second scutum not produced.

None of the North American species of this genus approach at all in size to the Spiroboli. The body is always slender, and seldom more than three inches in length. The head is distinct, and has the antennæ always more or less elongate and filiform, apparently

well adapted for active service. The second scutum is never produced forwards at the sides so as to abut against the head, as in Spirobolus. In all the species in which I have had an opportunity of examining sexes, the form of the first scutum distinguishes them with certainty. In the male its antero-posterior diameter is large, and there are well-marked lateral margins running nearly at right angles to the others. In the female the anterior posterior diameter is much less, but laterally the scutum is so produced that the anterior and posterior margins may in most cases be said to meet one another at an angle. The males are further distinguished by a peculiar alteration of the first pair of feet, which are transformed into a pair of very large, thick organs. The function of these is obscure, but possibly it may be connected with the union of the sexes, analogous to that of the "claspus" in some reptiles.

I. IMPRESSUS.

I. rubro-castaneus, linea dorsale nigra et maculæ nigræ seriebus lateralibus (interdum obsoletis) ornatus; antennis longis, filiformibus, pilosis, haud clavatis; scutorum lateribus canaliculatis; segmentis 52; mucrone parvo.

Reddish chestnut, ornamented with a black dorsal line, and a lateral series of black dots (sometimes obsolete); antennæ long, filiform, pilose, not clavate; sides of the scuta canaliculate; segments 52; mucro small.

I. IMPRESSUS, *Say*, Journ. A. N. S, 1st series, vol. ii, p. 102.
" *Gervais*, Apteres, vol. iv, p. 176; Exped. L'Amer. du Sud (Castelneau), Tabl. Myriap., p. 18; Brandt, Recueil, p. 84.

I. VENUSTUS, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 10.

The general color of this species is reddish chestnut; frequently the red predominates so much that the individual is really flesh-colored, but occasionally the chestnut overcomes the other tint. The dorsal stripe is generally very distinct, especially on the posterior portion of the scuta. The eyes are triangular, and are connected by a dark band, which is often rather obscure. The anterior cephalic aspect is long and narrow, with its sides converging inferiorly. Its inferior border is fringed with a double row of short, distant hairs, and is medianly deeply emarginate, and 2—4 dentate. The scuta are ornamented, rarely with a white blotch on each side of the mesial line, but generally with two lateral black dots. The first scutum in the female has the anterior margin oblique as to the main axis of the body, and is prolonged laterally so as to form processes, mostly canaliculate, with a rounded border. In the male the anterior margin is at right angles to the axis of the body, and the lateral parallel to it, so that there are no processes. The male appendages consist of two main portions on each side. The outer and more conspicuous of these (Figs. 27, 28) is formed of a thin, very irregular plate, from whose base springs a short, clavate, cylindrical, distally pilose process. The inner portion (Fig. 26) is composed

of a long, very slender, almost setiform process, and a shorter straighter one. The former at its base is bent at right angles to itself; and distally it is somewhat spirally arched over the other.

The female (Fig. 29) appendages consist of two broad, robust, pilose processes, with a pair of very slender, almost filiform, feet-like bodies, springing from their conjunction and equalling them in length. The major portion of each appendage is composed of a single plate. This is folded on itself, so as to constitute an irregular, flattened cylinder, which is open at its end and along the outer edge. It presents on one aspect an unbroken, tolerably regular surface, but on the other is proximally abbreviated. Through the opening thus afforded projects a pair of subcircular, somewhat globose plates, fitting together much as the shells of a bivalve. The filiform processes are on the former surface. Length, 2 inches.

Fig. 26. Fig. 27. Fig. 28. Fig. 29.



Hab. Illinois. Smithsonian Institution.—R. Kennicott. Georgia. Coll. A. N. S.—Dr. J. L. Le Conte, U. S. A.

In the Kennicott collection I have seen a male *Iulus* very closely resembling the former, but differing so much in its genital appendages that it probably represents a distinct species. The outer of the two parts, forming each appendage, consists of a thin, flat, crooked, very irregular process, and a shorter, robust, pilose, and strongly clavate one. The former, proximally, is quite broad, and narrows from the base, but distally is but at a right angle to itself, and is rapidly contracted, so as to terminate in a nearly cylindrical crooked point. The main process (Fig. 30) of the inner portion is somewhat cylindrical proximally, but is distally expanded. At first bent at a right angle to itself, it next has the swan-neck curve, and is then bent at an acute angle to itself to be straight the remainder of its length. At this angle there is a minute sharp spine. Shielded, as it were, by this process, there is another, very slender and acute.

Fig. 30



It is most probable that *I. venustus*, Wood, is the species intended to be indicated by Mr. Say under the name of *impressus*, although his description is so meagre that it could be applied to other species. The locality would seem to fix it, however. Mr. Say's description is given below in full.

"Brown, a series of lateral black dots, beneath yellowish white; ultimate segments mucronate."

"Body cylindrical, emarginate, above brownish, beneath yellowish white, appearing glabrous; segments each with a lateral black spot, whitish lines and dots sometimes obso-

lete, a transverse series of longitudinal, abbreviated, obsolete, impressed lines; and beneath the stigmata with impressed, more distinct ones, ultimate segment mucronate, spiracles not prominent; eyes rather large, conspicuous, black; labrum yellowish white; antennæ brownish."

"A common species inhabiting under stones, and in humid situations; a variety occurs with a very distinct, acute, longitudinal, dorsal line, and variegated head."

I. PILOSISCUTA.

I. castaneo-brunneus maculæ nigræ (interdum obsoletæ) seriebus lateralibus ornatus; antennis longe pubescentibus; capitis margine antico modice emarginato, denticulato; segmentis 58; mucrone parvissimo; scutis pilosis, singulo punctorum disjunctorum serie impresso.

Chestnut brown, ornamented with a lateral series of black dots (sometimes obsolete); antennæ pubescent; anterior margin of the head moderately emarginate, denticulate; segments 58; mucro very small; scuta pilose, each impressed with a series of distant dots.

I. PILOSISCUTA, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 11.

The color of this species is a chestnut brown, sometimes mottled with light brown. The anterior aspect is beautifully but irregularly areolated with the latter color. The antennæ are moderately long, and have their dark joints tipped with white. There is a pair of coarse punctations on the vertex. Each scutum has a series of distinct punctations extending entirely around it; from these dots proceed little channels, obsolete on the forepart of the body, but gradually becoming strongly pronounced. The anterior portion of the body is sparsely, but the posterior densely, pilose. The anal scales are very rough. I have never seen a male, neither can I give a detailed account of the female appendages, but one portion of them consists of a pair of short, subcylindrical, rather robust and distally clavate processes.

Hab. Susquehanna County, Pennsylvania.—E. D. Cope, Esq.

I. EXIGUUS.

Corporis segmenta cum anali 31 ad 33. Pedum paria 51 ad 55. Oculi subrotundi. Antennæ pilosæ, subbreves, articulis apicalibus approximatis, subincrassatis, quoad colorem fusco nigricantes, articulorum apicibus albidis. Cinguli primi supra epunctati processus lateralis trigonus, modice acutus, subelongatus, apice incurvato, striis aliquot impressis notato, abdomen attingens. Segmenta reliqua dorsalia parte posteriore subtumida, convexa, quare corpus submoniliforme, striis subremotiusculis, grossiusculis, in dorso subobsoletis, in lateribus distinctis impressa. Penultimum cingulum satis insigne, in posterioris marginis medio breviter mucronatum, mucronis apice pallide brunneo, anum vix superante. Valvulæ anales laterales pilosæ. Squama analis inferior triangularis postice mucronata. Caput nigrum, antice fuscescens, margine labiali flavicante-albido. Labium inferius fuscescens, margine anteriore flavicante-albido. Corpus totum fusco-nigrum, nitidum, abdomine pallidiore. In dorso medio,

exceptis cingulis anterioribus, fascia longitudinalis subfuscente-flava, linea puncta subfuscente-atra divisa. Pedes albido et fusco-variegati.

Longitudo $3\frac{3}{4}$ ad 4‴; latitudo $\frac{1}{3}$‴.*

I. EXIGUUS, *Brandt*, Recueil, p. 85.

" *Gervais*, Apteres, vol. iv, p. 177; Exp. Amer. du Sud (Castel.), Tabl. Myriap., p. 18.

Species mihi ignota.

I. OREGONENSIS.

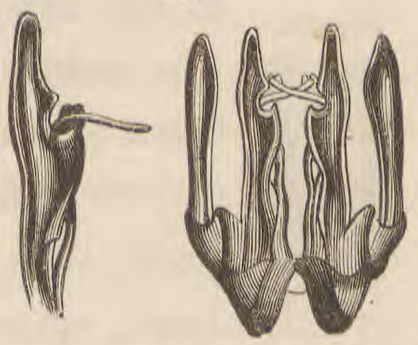
I. læte castaneus, albido-brunneo annulatus, et linea dorsale nigra et maculæ nigræ seriebus lateralibus ornatus; antennis filiformibus, longis, pilosis, subclavatis; capitis margine antico valde emarginato, denticulato; segmentis 44—45; scutorum lateribus canaliculatis; mucrone parvo, robusto; squama preanali triangulare.

Bright chestnut, annulate with whitish brown, and ornamented with both a black dorsal line and a lateral series of black dots; antennæ filiform, long, pilose, subclavate; anterior margin of the head strongly emarginate, denticulate; segments 44—45; sides of the scuta canaliculate; mucro small, robust; preanal scale triangular.

I. OREGONENSIS, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 11.

The color of this elegant species is a bright chestnut, ornamented with rings of a very light brown and a dorsal black line, as well as a black spot on the side of each scutum. In some individuals there is on the anterior portion of the first scutum a black crescentic blotch, and on the posterior a border of the same tint. The anterior aspect of the vertex is long and narrow and deeply emarginate inferiorly, where it is denticulate and fringed with two rows of distant hairs. The eyes are somewhat elliptical, and are connected by an illy defined black band. The posterior portion of the body is not pubescent. The outer piece of the male appendages (Fig. 31) is rather long, straight, and somewhat clavate, and distally pilose. The inner process is large, and is formed of a plate so folded longitudinally as to form a groove on the inner edge. From the base of the appendage springs a slender process, which soon bifurcates; the more slender of the divisions is the longer. They both soon enter the groove, before spoken of, the shorter and more robust being distal as to the other, and emerging from the groove on the other side of the main process, whilst the longer comes out on the same side as it enters. The female appendages are composed of a broad, thin piece, from which arise a pair of filiform, feet-like processes, besides two other very robust ones. These last are sparsely pilose, and about as long as broad. They

Fig. 31.



* This is copied from Mr. Brandt's description in Recueil, &c.

reach about to the base of the filiform bodies, and have a slit-like orifice in their summit.

Length of body, 2½ inches.

Hab. Oregon.—Smithsonian Museum.

I. CANADENSIS.

I. brunneo-castaneus, linea nigra dorsali et punctorum nigrorum seriebus lateralibus ornatus; segmentis 53; mucrone maximo, robusto, acuto, uncinato.

Brownish chestnut, ornamented with a black dorsal line and lateral series of black dots; segments 53; mucro very large, robust, acute, uncinate.

I. CANADENSIS, *Newport*, Ann. and Mag. Nat. Hist., vol. xiii, p. 268.
" *Gervais*, Apteres, vol. iv, p. 178; Exped. L'Amer. du Sud, Tab. Myr., p. 18.

I have seen specimens of this species and written a detailed description, which was destroyed at the Smithsonian fire. At present I am unable to obtain any specimens, and therefore am forced to give only a specific diagnosis from memory. Length, 2 inches. Fig. 32 is a drawing of the female organs.

Fig. 32.



Hab. Northeastern United States, Canada.

I. IMMACULATUS.

I. saturate rubido-brunneus, haud maculatus; antennis modice longis, filiformibus, vix subclavatis, pilosis; capitis margine antico modice emarginato; segmentis 48—51; scutis infra canaliculatis; mucrone magno, uncinato, robusto, acuto.

Deep reddish brown, not maculate; antennæ rather long, filiform, scarcely subclavate, pilose; anterior margin of the head emarginate; segments 48—51; scuta inferiorly canaliculate; mucro large, uncinate, robust, acute.

I. IMMACULATUS, *Wood*, Proc. A. N. S., 1864, p. 12.

The color of all our specimens is a very dark reddish brown, unrelieved by any other tint. On the vertex is a pair of coarse punctations, as in *I. Canadensis*. The lateral processes of the first scutum in the female, although small, are somewhat canaliculate. The mucro is certainly smaller than that of *I. Canadensis*. The male appendages are composed of two parts. The outer of these consists of a somewhat clavate and pilose process, with a curiously folded and contorted plate on its inner side. The other portion is formed of a straight process, which has several minute, spine-like bodies on its free extremity, and is proximally suddenly contracted, and then expand somewhat, so as to give an appearance of emargination. From the base of this springs another, almost filamentous process.

Fig. 33.



The female (Fig. 33) appendages consist of two bodies conjoined at their bases, and blunt at their free extremity. When viewed from one aspect they appear cylindrical, but, from the other, flattened or even concave; opposite to the latter face there is a broad, irregular piece, which has its free extremity scolloped.

Hab. Catskill Mountains, New York.—Dr. H. C. Wood, Jr.

I. PENNSYLVANICUS.

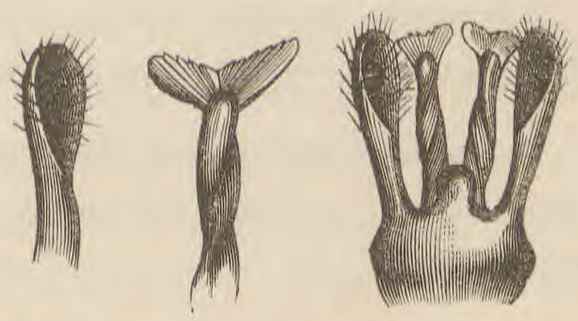
I. brunneus; antennis filiformibus, modicis, pilosis, vix subclavatis, articulis nigricantibus apicibus albidis; segmentis 63; mucrone recto, nonnihil breve; corpore postremo piloso.

Brown; antennæ filiform, moderate, pilose, scarcely subclavate, their articles blackish with whitish apices; segments 63; mucro straight, rather short; body posteriorly pilose.

I. PENNSYLVANICUS, *Brandt*, Recueil, p. 85.
" *Gervais* (Suit a Buffon), Apteres, vol. iv, p. 179.

The general color of this species is brown, but there is a series of lateral black dots around which the color is often much lighter. There is a pair of punctations on the vertex, which is traversed by a broad blackish band. The inferior portion of the head is light brown, often mottled. The labrum is moderately emarginate. Each scutum is furnished with a series of rather distant puncta, from each of which proceeds a more or less obsolete superficial groove.

Fig. 34.



The male appendages (Fig. 34) are composed on each side of two parts attached to the basal piece. The outer of these is nearly straight, though somewhat rolled on itself, and is distally enlarged and pilose. The inner part is formed chiefly of a thin, straight piece, very much rolled and twisted. Distally it is expanded into a very thin, transverse, diaphanous, alar process, with serrated edges.

Hab. Pennsylvania.

I. CANALICULATUS.

I. brunneus, interdum cæruleo tinctus; antennis filiformibus, pilosis, nonnihil clavatis; segmentis 51; scutis supra et infra arcte canaliculatis, singulo pilorum longorum distantium serie unica instructo; mucrone longo, recto; squamis analibus longe pilosis; squama preanali triangula, acuminata.

Brown, sometimes with a bluish tinge; antennæ filiform, pilose, somewhat clavate; segments 51; scuta both above and below closely canaliculate, each furnished with a single series of long distant hairs; mucro long, straight; anal scales with long hairs; preanal scale triangular, acuminate.

I. CANALICULATUS, *Wood*, Proc. A. N. S., 1863, p. 12.

The color of this species is a dark brown, with sometimes a bluish tint, and very generally mottled with light brown. The triangular eyes are connected by an obscure black band. The labial margin is broadly emarginate, and is furnished with two or three denticules, as well as a double row of distant rigid hairs. The joints of the antennæ are tipped with white. The first scutum is, in the female, slightly prolonged laterally, where it is rounded off; on its anterior surface there is a dark, somewhat crescentic, blotch. The anterior of the two subscuta, forming each scutum, is closely and deeply canaliculate through its whole circumference; it is broader than the posterior, and very slightly elevated, so as to give the body somewhat of a moniliform appearance. The ring of hairs surrounding each scutum is frequently imperfect; it may be from the handling of the specimen. The posterior subscutum is smooth above, and distantly and shallowly canaliculate below. The posterior portion of the body is very pilose. I have never seen a male. Length, 1½ inches.

Hab. Chester County, Pennsylvania.—Dr. H. C. Wood, Jr.

I. LAQUEATUS.

I. brunneus, interdum cæruleo tinctus; antennis filiformibus, pilosis, nonnihil clavatis; segmentis 49; scutis et supra et infra valde arcteque canaliculatis; mucrone longo et recto; squama preanali triangula, vix acuminata.

Brown, sometimes with a bluish tint; antennæ filiform, pilose, somewhat clavate; segments 49; scuta both above and below deeply and closely canaliculate; mucro long and straight; preanal scale triangular, scarcely acuminate.

I. LAQUEATUS, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 13.

The color of this species is brown, sometimes bluish, mottled, almost areolated, with light brown. The eyes are triangular, and are united by a dark band. The head has its anterior margin broadly emarginate, denticulate, and furnished with two rows of distant rigid hairs. The antennæ have their proximal joints nearly cylindrical, and are light colored, with their articles indistinctly tipped with white. The first scutum has rather small lateral processes, and is ornamented on its anterior border with a dark band. The anterior subscuta are deeply and closely canaliculate over the whole of their surface. The anal scales are furnished with a series of long hairs along their valvular margin. The posterior portion of the body is generally adorned with a very few scattered hairs, but I have never seen it pilose. Length, ¾ of an inch.

This species differs from *I. canaliculatus* in its smaller size, the absence of hairs on the anterior, and their paucity on the posterior portion of the body, and in the mucro being larger in proportion to the rest of the animal.

Hab. Chester County, Pennsylvania.—Dr. H. C. Wood, Jr.

I. CINEREFRONS.

I. brunneus, cinereo annulatus; capitis superficie antica cinerea; mucrone nullo; squama preanali triangula, haud acuminata.

Deep brown; antennæ filiform, long, pilose, clavate; scuta below deeply and closely canaliculate, above sometimes obsoletely so; segments 33; mucro none.

I. CINEREFRONS, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 13.

The color of this species is dark brown. The anterior surface of the head is an obscure gray color, with a dark band. There is between the upper and anterior surface of the head a well-marked angle, almost an elevated ridge. The lower margin is fringed with a few hairs, and is emarginate and armed with a few denticules. The triangular eyes are connected by a distinct, impressed line. On the upper portion of the anterior surface of the head are two round, light dots, surrounded by a darker tint. The antennæ are wanting in the only specimen, a female, that I have seen, which is so mutilated that I cannot say certainly of how many segments it was composed; the number, however, was probably either thirty-four or forty-five. The first scutum has very small, lateral processes. It is light brown, bordered with a dark band, edged with a grayish tint. The anterior portion of the body is of a lighter shade than the posterior, and has the grayish annuli more distinctly pronounced. The anal scutum is not mucronate. The anal scales are not pilose.

Hab. Oregon.—Smithsonian Institution.

I. MILESII.

I. saturate brunneus; antennis filiformibus, longis, pilosis, clavatis; scutis infra arcte et valde, supra interdum obsolete, canaliculatis; segmentis 33; mucrone nullo.

Brown, annulate with ash color; anterior surface of the head cinereous; mucro absent; preanal scale triangular, not acuminate.

I. MILESII, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 13.

The color of this species is a very dark, almost black brown; but the anterior portion of the body, and especially the head, is lighter. The antennæ are very pilose, and quite strongly clavate. The eyes are connected together by a black band. The anterior scuta have their lateral surfaces closely and deeply canaliculate, but are almost smooth on their upper surface. The posterior are everywhere deeply channelled, although more so below than above. There are a few hairs on the anal scales. The anal scutum is not mucronate. It affords me pleasure to dedicate this species to Professor Miles, who is laboring so assiduously and successfully to develop the zoology of Michigan.

Hab. Michigan.—Collection State Agricultural College. Professor Miles.

I. CÆRULEO-CINCTUS.

I. brunneus, saturate cæruleo annulatus; segmentis 42; antennis parvis; scutis infra et supra modice canaliculatis; mucrone nullo.

Brown, annulate with deep blue; segments 42; antennæ small; scuta both below and above moderately canaliculate.

I. CÆRULEO-CINCTUS, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 14.

The color of this species is brown, with a dark, sometimes obsolete ring of blue to each segment, except the most anterior. The lower portion of the anterior surface of the head is light brown. The labial margin is scarcely emarginate, but is rounded and fringed with rigid hairs. The eyes are arranged in subtriangular patches, with their transverse diameter much the greater. They are connected by a black band, which is much broader in the middle than at the ends. The first scutum is large, with very small lateral processes even in the female. There is on its anterior edge a very obscure light border, and a little posterior to this a black, more or less obsolete, band. The scuta are regularly, although rather lightly and distantly canaliculate over their whole surface. The last scutum is distinctly but minutely punctate, has its edge whitish, and is not at all mucronate. The anal scales are not at all pilose. The specimens from which this description is taken are in so bad a condition that I have hesitated to notice them. But probably the description will be found to be sufficiently accurate for the identification of the species. Length of body about 1½ inches.

I. HORTENSIS.

I. brunneus, lateribus maculis nigris ornatis; antennis modice brevibus, pilosis, filiformibus, clavatis; segmentis 42; scutis arcte canaliculatis et infra et supra; mucrone nullo; squama preanali triangula, apice rotundato.

Brown, ornamented with black spots on the sides; antennæ rather short, pilose, filiform, clavate; segments 42; scuta closely canaliculate both above and below; mucro absent; preanal scale triangular, with its apex rounded.

I HORTENSIS, *Wood*, Proc. A. N. S., 1864, p. 14.

The general color of this species is rather dark brown in the adult. When an individual is examined with a magnifier, it is seen to be beautifully areolated with light brown. In young specimens and adults, which have recently shed their exuviæ, the color often verges on white, whilst the side spots are black, contrasting strongly with the general tint. The head is rather broad inferiorly, and has its lower margin shallowly emarginate, and distinctly, though minutely, denticulate. The triangular eyes are connected by a broad, dark band. The first scutum is ornamented on its anterior portion by a dark, transverse band. The lateral processes are almost wanting, even in the female. There is on each side a series of large, black dots, one to a scutum, commencing rather abruptly at about the fifth or sixth segment, and ending in the same way at about the thirty-ninth. The subscuta on which they are situated are scarcely canaliculate. The anal scutum is about equal in length to the two preceding it. Length, ½ to 1 inch.

Hab. Philadelphia.—Dr. H. C. Wood, Jr.

I. VIRGATUS.

I. saturate brunneus; dorso luteolo, medio linea nigra instructo; antennis modice longis, pilosis, clavatis; segmentis 35; scutis copiose distincte canaliculatis; mucrone subnullo; squamis analibus sparse pilosis; squama preanali lata, subtriangula, apice rotundato.

Deep brown; dorsum yellowish, furnished with a median black line; antennæ moderately long, pilose, clavate; segments 35; scuta copiously distinctly canaliculate; mucro almost wanting; anal scales sparsely pilose; preanal scale broad, subtriangular, with rounded apex.

I. VIRGATUS, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 14.

The sides of the body are deep brown, almost black, whilst the dorsum approaches a yellowish fawn color, and has a strongly pronounced, black median line. The lower margin of the head is broadly emarginate, denticulate, and fringed with a series of hairs. The anterior surface is mottled with light brown, and has a dark median band, terminating in a transverse one low down. The under surface of the body is light-colored, and is often somewhat areolated. There are some specimens whose pattern of coloration is light brown or fawn colored, with two lateral and one median dark stripe. Are these

individuals which have recently cast off their exuviæ? The eye-patches are somewhat parabolic. The joints of the antennæ are obconical, dark colored, and tipped with white. The lateral processes are small. The grooving of the scuta is in some specimens somewhat obsolete on the dorsum. The posterior scutum is light colored. I have never identified a male. Length, ½ to ¾ of an inch.

Hab. Philadelphia.—Dr. Joseph Leidy, Dr. H. C. Wood, Jr. Washington, D. C.—F. W. Putnam.—Collection Museum Comp. Zoology.

I. STIGMATOSUS.

"Body brownish, with an impressed dorsal line, impressed white dots and spots; ultimate segments unarmed.

"Body cylindrical, emarginate, above dark brown, glabrous, an obsolete, dorsal, whitish, slightly impressed, acute line; segments each with a white dot on either side above, and a larger transversely oblong lateral one, which is gradually more completely bisected on the posterior segments into two distinct dots, which on the terminal segments resemble the dorsal ones; ultimate one abruptly narrower than the preceding and truncated; anterior segments attenuated to the head, which is wider than the anterior one; anterior segment as long as the second and third ones conjointly; spiracles somewhat prominent; eyes very distinctly granulated, subtriangular, black; head dark brown; labrum white."

IULUS PUNCTATUS, *Say*, Journ. A. N. S., new series, vol. ii, p. 102.
I. STIGMATOSUS, *Brandt*, Recueil, p. 88.
" *Gervais*, Apteres, vol. iv, p. 179; Exp. L'Amer. du Sud, Tabl. Myriap., p. 18.

Species mihi ignota.

I. MINUTUS.

"Body with a lateral series of black dots, terminal segments unarmed."

"Body cylindrical, emarginate, above pale, obsoletely reticulate, and varied with reddish; a lateral series of large black spots, numerous longitudinal impressed acute lines beneath the stigmata becoming gradually shorter to the origin of the feet, beneath whitish; head white beneath the antennæ; antennæ two joints preceding the last, somewhat dilated, not attenuated at their bases, nor separated by a contraction; eyes black, longitudinally sublunate; ultimate segments unarmed longer than the penultimate one, rounded at tip and blackish. Length nearly half an inch. Common on the Eastern Shore of Virginia."

I. PUSILLUS, *Say*, Journ. A. N. S., new series, vol. ii, p. 105.
I. MINUTUS, *Brandt*, Recueil, p. 89.
" *Gervais*, Apteres, vol. iv, p. 178; Exp. L'Amer. du Sud, Tabl. Myriap., p. 18.
I. SAYII, *Newport*, Ann. and Mag. Nat. Hist., vol. xiii, p. 268.

Species mihi ignota.

Genus SPIROBOLUS.

Scuti primi latera brevia, haud producta. Scuti secundi latera longe producta, cum superficiebus anticis triangulis.

Sides of the first scutum short, not produced. Sides of the second scuta very much produced, with anterior triangular surfaces.

Spirobolus, *Brandt*, Recueil, p. 114.

The form and general appearance of this genus is very different from that of the true Iulus. The great size and thickness of the body, and the peculiar way in which the head is set into it, so to speak, attract the first glance of the observer. The head is generally not proportionally very large. The antennæ in our American species (except angusticeps?) are very short, and often lie almost hidden in a groove in the side of the head, bent so as to form a right-angled "knee," with their free end directed downwards.

The eye-patches are of various shapes, and, though large, are generally not very prominent. The first scutum is broad, antero-posteriorly, with its sides more or less obliquely truncate. The second scutum has its sides much produced and bent forwards, so as in a measure to embrace the first scutum. Where it abuts against the head there is on each side a triangular surface.

In all the species which I have examined, the male appendages are formed after one very peculiar type, with marked specific differences in the minutiæ of their forms. This may prove to be generic. In the true Iulus no appendages have as yet been described agreeing with this pattern.

S. marginatus.

S. saturate brunneus, rubeo annulatus; capite copiose minute punctato, antico punctorum maximorum serie instructo; segmentis 53—57; scutis copiose minute punctatis; squama anale triangula.

Deep brown, annulate with red; head copiously minutely punctate, furnished anteriorly with a series of large puncta; segments 53—57; scuta copiously minutely punctate; anal scale triangular.

Iulus marginatus, *Say*, Journ. Acad. Nat. Sci., 1st series, vol. ii, p. 105.
" " *Gervais*, Apteres, vol. iv, p. 180; Exped. L'Amer. du Sud (Castelneau), Myriap., p. 19.
" " *Brandt*, Recueil, p. 89.

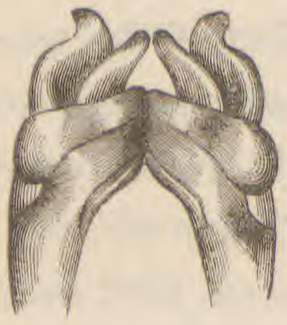
S. marginatus, *Newport*.

? Iulus Americanus, *Pal. Beauvois*, Insect. Afrq. et Amer., p. 155.
? Iulus incertus, *Brandt*, Recueil, p. 121.
Iulus ornatus, *Girard*.
? Iulus atratus *Girard*, Marcy's Report, Expl. Red River of the South, p. 274.

The color of this species is a very dark brown, sometimes with a reddish, sometimes with an olive or even bluish tint. The head is quite deeply emarginate. The vertex furrow is pronounced. The first scutum is margined with deep red both anteriorly and posteriorly. The posterior borders of the other scuta are furnished with a narrow, dark brownish, red margination.

The male appendages (Fig. 35) are formed of two outer parts and the yoke-like piece which connects them. The former are composed of the following parts: First. A thin plate bent around the inner portion; this is deeply notched laterally, but presents on one aspect a long, low, smooth surface; on the other it is produced into a broad process, rapidly narrowing and terminating distally in a very narrow, blunt portion, which is abruptly bent on itself, but does not form a hook. Next within this is a large, thick, blunt, curved process, composed of a plate so bent on itself as to make a sort of sheath, in which lies a thin, flat, blunt, slightly falciform process.

Fig. 35.



Hab. United States.

M. Girard has described two species of Iulus from the Southwest, atratus and ornatus. His description of the latter applies to I. marginatus. I have seen the type of I. atratus, but unfortunately in such a bad state of preservation that I am unable to decide with certainty its claims to rank as a species; it is, probably, however, nothing more than a variety. The descriptions of M. Girard are given below in full.

I. ORNATUS.

"*Spec. Char.*—Ground-color bluish black; segments narrowly margined posteriorly with reddish; anterior margin of segments rather blue, whilst the middle is rather black, thus giving the appearance of three rings of color. The anterior portion, which is covered by the articulation, is fulvous. Feet deep chestnut-brown. Antennæ rufous at base, blackish at tip. Stigmata not conspicuous, marked by a series of small obsolete blackish spots."

"*Remarks.*—This species is allied to Iulus marginatus of Say, but the body is proportionally much stouter. The ocelli are disposed upon a subtriangular space quite different in shape. The antennæ themselves are slenderer in proportions. The labrum (upper lip) is also less emarginated than in Iulus marginatus, and the marginal punctures much less conspicuous."

I. ORNATUS, *Girard*, Marcy's Report, Exploration Red River of the South, p. 274.

I. ATRATUS.

"*Spec. Char.*—Body, feet, and antennæ, uniform deep blackish brown; antennæ and feet

occasionally reddish, as also the labrum and anterior margin of first segment. Posterior third of each segment of a shining black. Stigmata and lateral striæ beneath quite conspicuous."

"*Remarks.*—Resembles more *Iulus ornatus* than *I. marginatus* in the general proportions of the body, but in the structure of the antennæ and labrum comes nearer to *I. marginatus*."

I. ATRATUS, *Girard*, Marcy's Report, p. 274.

S. UNCIGERUS.

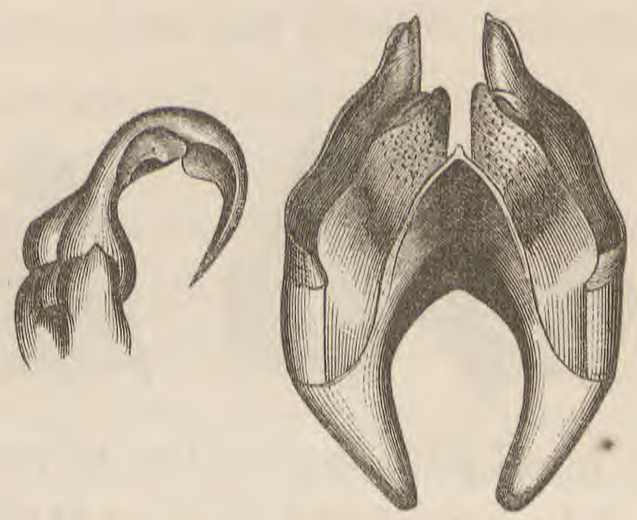
S. læte brunneus, saturate-rubeo-brunneo annulatus; capite sparse minute punctato et corrugato, antico punctorum maximorum serie instructo; segmentis 50—53; scutis supra et copiose punctatis et corrugatis; squama anale triangula.

Bright brown, annulated with deep reddish brown; head sparsely minutely punctate and corrugate, anteriorly furnished with a series of large puncta; segments 50—53; scuta above both copiously punctate and corrugate; anal scale triangular.

S. UNCIGERUS, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 15.

The color of this species is a bright brown, with an annulus of dark reddish brown on the posterior border of each segment. The head is distinctly medianly canaliculate, except in the centre, and has the row of dots on its anterior face, as in *S. marginatus*, but is not as decidedly punctate elsewhere as in that species. The eyes are triangular. The antennæ closely resemble those of *S. marginatus*, but are, perhaps, rather shorter and more compressed. The first scutum is banded, both anteriorly and posteriorly. The lateral processes, even the female, are almost wanting. The second scutum is produced forwards as in *S. marginatus*. The male appendages (Fig. 36) are composed of a yoke-like piece and two outer parts, which it connects. The central piece may be described as formed by two plates (although but really one) meeting at an angle in the centre and attached to the outer parts at their other extremities. These outer articles are formed each as follows: First. There is a large plate which is bent around an inner basal piece, and is deeply notched laterally, but is produced anteriorly into a broad, almost rudely punctate plate, and posteriorly into a short, slender process, terminating in an imperfect hook. This last process is sometimes obsolete. Second. Articulating with the

Fig. 36.



inner basal piece, alluded to, there exists a large, strongly-curved, acute hook or claw, whose distal extremity is subcylindrical. The female appendages are small, and are composed on each side of a very thin plate and a process about a line in length, proximally irregularly prismatic in shape; but distally excavated suddenly, so as to be flattened for the remainder of its course.

Hab. California.—Smithsonian Institution.

S: ANGUSTICEPS.

S. niger, lateribus brunneo maculatis; capitis superficie antica angusta, longa, supra nigra, infra albido-brunnea; antennis ?; segmentis 75; scutis et infra et supra distincte canaliculatis; squama anali triangula.

Black, with the sides maculate with brown; anterior surface of the head narrow, long, above black, below whitish brown; antennæ ?; segments 75; scuta both above and below distinctly canaliculate; anal scale triangular.

S. ANGUSTICEPS, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 16.

The color of this species is black, with a brown band on the sides, in which is a black dot marking the position of the lateral pores. The lower portion of the head is very light-brown, and is rather deeply emarginate. Along the posterior cephalic border is a somewhat crescentic area, which is nearly smooth and is medianly canaliculate; adjoining this the surface suddenly is rudely punctate, but gradually becomes smoother. The eyes are arranged in three transverse rows, the posterior being much the longer. The first scutum is copiously coarsely punctate, and is posteriorly slightly canaliculate on the dorsum, but distinctly so on the sides. The lateral processes, even in the female, are obsolete, the second scutum being produced forwards so as to abut on the head. The posterior subscuta are on the dorsum closely, rather deeply, and more or less obliquely canaliculate, but on the sides less distinctly and more distantly so. The anterior subscuta are very distantly and much more lightly and obliquely canaliculate, and are also more closely channelled below than above. The surface of the anal scutum is irregularly and minutely corrugate. I have seen but one imperfect specimen—a female. The female (Fig. 37) appendages appear to consist of two conoidal bodies coalescing at their bases and united together towards their apices by a broad plate, so placed as to present towards them an inclined surface. Into the base of these pyramidal processes fit other somewhat prismatic bodies (Fig. 37 *a*), with their thin edge formed of several pieces. Length, 4½ inches.

Fig. 37.

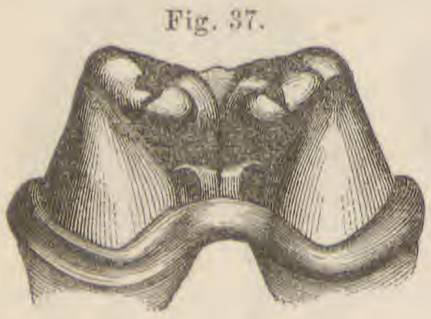


Fig. 37 *a*.



Hab. San Francisco.—Smithsonian Institution.—R. D. Cutts.

S. SPINIGERUS.

S. fulvus, maculis saturate viridis maximis ornatus; capite minute punctato, infra punctorum magnorum serie instructo; oculis suborbiculatis; antennis longis; segmentis 48; scutis leviter sparse punctatis; squama preanali triangula.

Fulvous, ornamented with very large deep-green maculæ; head minutely punctate, furnished inferiorly with a series of large puncta; eyes suborbicular; antennæ long; segments 48; scuta sparsely lightly punctate; preanal scale triangular.

S. SPINIGERUS, *Wood*, Proc. Acad. Nat. Sci., 1861, p. 15.

The color of this species is fulvous, often varying towards orange. On each scutum there is a large dark-green transverse crescentic blotch. This is often so wide superiorly as to involve the whole of the dorsum. In some individuals there are lateral series of white blotches, and occasionally a black line on each side. These are, however, not common. The head has a strongly pronounced median furrow, and is greenish superiorly. The eye-spots are somewhat orbicular, with occasionally a tendency to become tetragonal or polygonal. The antennæ are longer than in *S. marginatus*. The scuta are not rough, and are very lightly or even obsoletely furrowed beneath. The spines on the inferior surface of the legs are very numerous and acute. The male (Fig. 38) appendages are formed of two main portions joined together, as in *S. marginatus*. The large plate of the main process is broad. The upper border of its face has a wavy outline. Externally it is produced into an alar portion, which ends in a blunt process at right angles to it. The inner piece is composed of a basilar and superior joint. The basilar is very long. The other (Fig. 39) is curved,

Fig. 38.



Fig. 39.



and presents on one aspect a strongly convex, on the other a strongly concave surface. It ends in a blunt point, and is armed with a large blunt process and an acute spine. The female appendages appear to consist on each side of a process deeply placed within the body,—this is thin on its free margin, which is rounded, though somewhat acuminate; below it is contracted and thickened. The three pairs of feet immediately in front of the genital aperture in the male have their coxæ produced into long processes. These are often of a curious form, but do not seem constant in this. The fourth and even fifth coxæ have small processes.

Hab. Florida. South Carolina.—Smithsonian Institution.

S. ANNULATUS.

"Body with numerous, elevated, obtuse lines, of which four are above the stigmata; ultimate segment glabrous, unarmed."

"Body cylindrical, emarginate, above brownish with a slight tint of red, immaculate, beneath yellowish white; segments each with about fifteen elevated obtuse lines, of which four are equal dorsal, a pyriform larger oblique one on the stigmata, and about ten decreasing in size to the feet, anterior segment as long as the three succeeding ones conjunctly and glabrous, posterior one glabrous reddish brown, as long as the two preceding ones, united and obtusely rounded at tip; head whitish before; antennæ white; eyes transverse linear, black; vertex not distinctly impressed."

I. ANNULATUS, *Say*, Journ. A. N. S., 1st series, vol. ii, p. 103.
S. ANNULATUS, *Newport*.

Species mihi ignota.

FAM. POLYDESMIDÆ.

Sterna et scuta arcte conjuncta; scuta laminis lateralibus instructa.

Sterna and scuta closely cemented together; scuta furnished with lateral lamina. (Fig. 40.)

The head in the Polydesmidæ is large and massive. The absence of eyes and the small antennæ point to a state of low development of the special senses. The female genitalia are placed in the third segment, just posterior to the second pair of legs. They are generally more or less hidden within the body. The male organs are situated in the seventh segment, replacing the eighth pair of legs. They generally project from the body so as to be very prominent.

Fig. 40.



Authors generally have divided this family into genera, founded upon the size and form of the lateral lamina. But, as H. De Saussure (*loc. cit.*) has remarked, these characters are relative, and the differences so merge into one another that the groups cannot be well defined or separated by distinct border lines. He therefore has very properly adopted these groups as subgenera. Fontaria, he thinks, has more claims as a distinct genus than the others, but even this is scarcely worthy of the higher rank. He takes for his generic characters the position and numbers of the lateral pores. In this I have followed without feeling sure but that at some future time still better characters will be elucidated. Two forms herein described apparently do not belong in the

genus Polydesmus, as defined by H. De Saussure; but, not being entirely certain that my specimens are adults, I have refrained from indicating a new genus.

When surface markings exist on the scuta, they are very useful in defining species. The color is also a good character in some groups. Where one of these fails us the other very generally assists. The form of the last scutum is sometimes distinctive. The best characters, however, are those derived from the genital organs. The form, &c., of the antennæ and head often afford some clue.

Genus POLYDESMUS, *Latreille.**

Meatus laterales in scutis 5—7—9—10—12—13—15—16—17—18—19—positus.

Lateral pores situated upon the 5—7—9—10—12—13—15—16—17—18—19—scuta.

Polydesmus, *H. De Saussure*, Mem. Soc. Nat. Hist., Geneva, vol. xv, p. 292.

Subgenus POLYDESMUS.

Dorsum complanatum. Laminæ laterales magnæ, horizonti ad libellam respondentes.

Dorsum complanate. Lateral lamina large, horizontal.

P. setiger, sp. nov.

P. brunneus; scutis squamis obtusis parvissimis (interdum obsoletis) ornatis; laminis lateralibus marginibus acute valdissime serratis.

Brown; scuta ornamented with very small, obtuse (sometimes obsolete) scales; lateral lamina with their margins acutely and very strongly serrate.

The head is broad, and has its anterior surface pubescent. The antennæ are rather long, filiform, pubescent, and strongly clavate. The first scutum is transversely oval. It is narrower than the head. The surface of the scuta is covered with minute flattened tubercles. On the more anterior these are quite distinct and arranged somewhat regularly in a fourfold series. On the more posterior they become less and less distinct, so that in some individuals these scuta have scarcely more than a rough appearance. Many of these tubercles are seta-tipped, and on the posterior borders of the scuta they become conical and acute, each with its rigid hair forming a sort of fringe. The lateral laminæ are broad and not widely separated. The serrations are less strongly pronounced on the

* As Latreille was the original describer of the genus Polydesmus, of course his name must be connected with it. But the genus, as here adopted, was first defined by H. De Saussure.

posterior than the anterior. The last scutum is triangular with its apex prolonged and decurvate.

The specimens which I have examined have only eighteen segments each, exclusive of the head, and of these there are lateral pores on only the 5—7—9—10—12—13—15—16—17—as in the following species. The more obvious specific differences between this species and P. granulatus, Say, are the following: The side plates are broader and closer together, and much more deeply serrate on their margins. Whilst in P. granulatus the squama on the scuta are more pronounced, less conical and acuminate, and never seta-tipped.

Hab. Pennsylvania.—Dr. H. C. Wood, Jr.

P. GRANULATUS.

P. brunneus; scutis squamis obtusis convexis in serie quadruplici dispositis ornatis.

Brown, scuta ornamented with a fourfold series of obtuse, convex scales.

P. GRANULATUS, *Say*, Journ. Acad. Nat. Sci., 1st series, vol. ii, p. 107.
" *Gervais*, Suit. a Buffon, Apteres, vol. iv, p. 104.

The head has its anterior surface covered with numerous short rigid hairs, causing it to appear pubescent. The antennæ are rather long, pubescent, and clavate. The first scutum is transversely oval, narrower than the head. The lateral lamina are not very large, and are separated from one another by broad intervening spaces. The anterior are deeply and acutely serrate; the others slightly serrulate. The oval surfaces of the scuta are covered with convex, obtuse tuberculoid scales, arranged in four more or less regular transverse rows. The last scutum is triangular, with its apex somewhat prolonged and decurvate; it is shortly pilose. I dissected the sexual organs of the only male which has come under my notice, but unfortunately the detailed description was lost at the Smithsonian fire. If my memory serves me right, the proximal portion of the spine is robust and very nearly straight; its distal extremity (Fig. 41) is swollen into a sort of knob-like process, from which arise two slender curved processes, one of which is slightly bifid, whilst the other is remarkable for being articulated by means of a movable joint.

Fig. 41.



All of the specimens examined have only nineteen segments, exclusive of the head, and of these the eighteenth and nineteenth are without lateral pores. This would remove the species from the genus Polydesmus (as here defined) were it certain that the specimens are adults. They have been collected at different localities, but still may not be fully developed, although they have the appearance of being so. Mr. Say's description will apply

very readily to the preceding species, but it seems to me to fit this one rather more closely, and as the choice must be somewhat arbitrarily made in the absence of proof as to which he intended, I think the name should be allowed to rest here. Length, ½ inch.

Hab. Pennsylvania.—H. C. Wood, Jr., M.D. Michigan.—Prof. Miles. Canada.—Prof. Dawson.

P. SERRATUS.

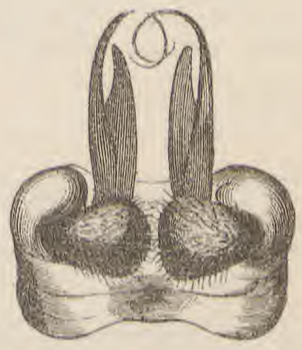
P. saturate brunneus; antennis pubescentibus, clavatis; scutis, singulo squamarum seriebus duabus et altera obsoleta ornato, marginibus lateralibus serratis; appendicibus masculis pilosis, spina terminale duplica. (Fig. 42.)

Deep brown; antennæ pubescent, clavate; scuta each with two rows of squama and a third obsolete series, their lateral margins serrate; male appendages pilose, their terminal spine double.

P. SERRATUS, *Say*, Journ. Acad. Nat. Sci., 1st series, vol. ii, p. 106.
" *Gervais*, Suit. a Buffon, Apteres, vol. iv, p. 105; Exped. L'Amer. du Sud (Castelneau), Myriap., p. 6.
" *Newport*, Cat. Brit. Mus. ?

The pilose anterior aspect of the head is quite broad and triangular, with the vertex furrows strongly pronounced. The first scutum is transversely oval, with three rows of elevated, obtuse, minute scales. On most of the other scuta there are two series of similar larger scales, with an obsolete series of very broad ones in front of them. The posterior row is generally composed of six, the next of four. The lateral lamina are large, and have their margins much more serrulate than in P. Canadensis. The last scutum is triangular and decurvate. The prominent knob-like portion of the male appendages is very hairy. The terminal spine is double, one portion being much more robust than the other, blunt and nearly straight. The longer piece is distally very slender and bent over the other.

Fig. 42.



Length ¾ of an inch.

It will be seen, on comparison of my description with the original one of Mr. Say, that it differs somewhat. The fact of Say's not mentioning the existence of the obsolete series of scales on the anterior surface of the scuta, has been the cause of M. Saussure's error. After carefully going over the whole ground, there is but little doubt in my mind that this is the species meant to be indicated by Say. If not, it is an undescribed species, and the real P. serratus has not yet come to light. It is an unfortunate fact that the earlier descriptions of Myriapoda are by no means exact, the authorities not appearing to have had any definite idea as to what constituted *specific* characters. If we interpret their records too closely, we may be led to false deductions.

Hab. Pennsylvania, &c.

"*Stenonia hispida.* Body composed of seventeen double segments, distinctly divided on the dorsal mesial line. Body depressed, margins of segments quite prominent and curved forwards near the head, in the middle and posteriorly transverse or curved slightly backwards. Surface of each segment covered with five rows of distinct tubercles, arranged somewhat in quincuncial order. From the direction of the tubercles the lateral and posterior margins of each segment appear serrated. First cervical segment smaller than the next, rounded anteriorly, straight and narrower behind, and obliquely truncated on the sides. The posterior segment about equal to the next in length, is triangular, the apex armed with a stiff hair. Color pale red above, feet and ventral surface flesh colored.

Length 6″. Under decayed logs."

Sager, Proc. Acad. Nat. Sci., 1856, vol. viii, p. 109.

I have never seen a specimen corresponding entirely with this description. Is it possible that Mr. Sager's species is either *P. serratus*, Say, or *P. setiger*, Wood?

P. CANADENSIS.

P. saturate brunneus; antennis pubescentibus, vix clavatis; scutis, singulo squamis 8 in serie duplici dispositis ornato, marginibus lateralibus obsolete serratis; appendicibus masculis (Fig. 43) pilosis, spina terminale modica, curvata.

Deep brown; antennæ pubescent, scarcely clavate; scuta each ornamented with 8 squama, arranged in a twofold series; lateral margins obsoletely serrate; male appendages hairy, their terminal spine moderate, curved.

P. CANADENSIS, *Newport*, Ann. and Mag. Nat. Hist., vol. xiii, p. 265; Catal. Brit. Mus., Myriap.
" *Gervais*, Suit. a Buffon, Apteres, vol. iv, p. 106; Exp. L'Amer. du Sud (Castelneau), Myriap., p. 6.
"P. SERRATUS, *Say*," *H. De Saussure*, Mem. Soc. Nat. Hist. Geneva, vol. xv, p. 325.

The color of this species is a dark brown, verging somewhat towards a chestnut, with, in some individuals, still more of the red. The median furrow of the vertex is strongly pronounced. In other respects the head agrees with that of P. cerasinus. The antennæ are rather more pubescent than in that species. The scuta are ornamented with a double row of scales on their posterior surface. These rows are composed each of four broad rectangular scales. There is frequently on each side a raised convexity or umbo lying outside of these. The serratures in the lateral margins of the side plates are very minute and frequently entirely obsolete. The last scutum is triangular, with its obtuse apex decurvate. The male

Fig. 43.



Fig. 44.



appendages (Fig. 43) are moderate. They have a small falciform spinule placed close to their side. The terminal spine springs from a knob-like portion, which is quite hairy and regularly curved. Its margin is irregularly notched near its middle, and its distal portion is curiously fringed. The female appendages (Fig. 44) consist of a pair of bodies shaped somewhat like the crest of a helmet. Along their free margin is an opening surmounted by a double series of teeth-like processes. I think a careful examination will convince any one that M. Saussure (*loc. cit.*) has described this species, under the name of P. serratus, thinking it was the one indicated by Mr. Say.

Length 1½ inches.

Hab. Pennsylvania, New Jersey, Illinois, &c.

P. CERASINUS.

P. dilute cerasinus; dorso complanato; antennis modice pubescentibus, nonnihil clavatis, nonnihil brevibus; scutis squamis obsoletis ornatis, marginibus lateralibus serratis; appendicibus masculis spina terminale lata, oblique truncata, utrinque processu longo setaceo curvato instructa. (Fig. 45.)

Light-cherry red; dorsum complanate; antennæ moderately pubescent, somewhat clavate, rather short; scuta ornamented with obsolete squamæ, their lateral margins serrate; terminal spine of the male appendages broad, obliquely truncate, furnished on each side with a long, curved, setaceous process.

P. CERASINUS, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 8.

The head has the median furrow on its vertex illy pronounced. The anterior face is sparsely pilose, and has its lower margin broadly but shallowly emarginate. The scuta have a double row of scales, obsolete, but otherwise similar to those of the following species; sometimes these are entirely lost. The lateral margins of the side plates are rounded slightly and minutely serrulate. They seldom have more than three serratures on each side. The terminal scutum is triangular, with its obtuse apex bent downwards. It is sparsely pilose. The legs are quite hairy and light-colored. Their second joint is tumid. The appendages (Fig. 45) in the male are peculiar. The terminal spines are broad and short, and superiorly very obliquely truncated, with two small hamular processes. On each side a long, seta-like process springs from the base. The outer, much the longer of the two, throws an arch entirely over the short spines. The inner is straighter. They both have one or two thorn-like excrescences.

Fig. 45.



Hab. Oregon.—Museum of Smithsonian Institution.

Subgenus PARADESMUS.

Dorsum modice convexum. Laminæ laterales magnæ,—horizonti ad libellam respondentes.

Dorsum convex. Lateral laminæ large, horizontal.

P. erythropygus.

P. olivaceo-castaneus; scutis postice aurantiaco maculatis; laminis lateralibus aurantiacis; scuto anale vix triangulare; appendicibus masculis modice robustis, spina terminale gradatim curvata, spinulo breve lato acuto armata, ultima bifida. (Fig. 46.)

Olive-chestnut; scuta posteriorly maculate with orange; lateral laminæ orange; anal scutum scarcely triangular; male appendages moderately robust; their terminal spine gradually curved, distally bifid, armed with a short, broad, acute spine.

P. erythropygus, *Brandt*, Recueil, p. 134.
" *Gervais*, Suit. a Buffon, Apteres, vol. iv, p. 106; Exped. L'Amer. du Sud (Castelneau), Myriapoda, p. 6.
" *Saussure*, Mem. Soc. Nat. Hist. Geneva, vol. xv, p. 296.

P. Carolinensis, *Saussure*, Mem. Soc. Nat. Hist. Geneva, vol. xv, p. 295.
" *Gervais*, Exped. L'Amer. du Sud (Castelneau), Myriap., p. 14.

The general color of this elegant species is an olive-chestnut; in some individuals the olive overpowering the other tint, and approaching sometimes to a slate color; in others the chestnut predominating. The color is not uniform, it shading darker and darker towards the maculæ. The latter are somewhat semicircular, bright orange, and placed on the posterior margin of the scuta. In most specimens there is a well-marked, black dorsal line. The vertex furrow is strongly pronounced. The anterior surface of the head has a pair of almost obsolete punctiform impressions, and is scarcely emarginate. The antennæ are coarsely pubescent, and not clavate. The first scutum frequently has an orange spot on its anterior margin. The last scutum has its posterior portion very broad, thin, and of an orange hue. The lateral laminæ are larger than in P. hispidipes; and their edges, though thickened, are not so much so as in that species. They are bright both on their upper and under surfaces. The feet are somewhat hairy, and, with the under surface of the body, of a dull-yellow color. The terminal spine of the male appendages has something of the swan-neck curve; on one of its surfaces there is a thorn-like spinule; distally it is shortly bifid. The female appendages (Fig. 47) are composed of a

Fig. 46.



Fig. 47.



basal portion supporting a reniform piece. This is hairy, especially along its free margin, where there is a linear opening.

I think there is not much doubt of the correctness of the surmise of H. De Saussure, that his Carolinensis is merely Brandt's erythropygus with the color altered by drying, &c.; but, that no mistake may be made, I append the description of Saussure.

Hab. Western Pennsylvania.—R. J. Walker, Esq. Illinois.—R. Kennicott, Esq. Smithsonian Collection.

P. Carolinensis.

"Depressus, politus, fuscus (albidus); dorsi medii maculis et carinis carneis; carinæ subcontinuæ, truncaturâ quadrangulâ, marginatæ; anguli antici dente minuto; pori laterales.

Saussure, Linnæa Entomologica, xiii, 1859, p. 325.

♀. Forme grêle, allóngée. Carènes peu longuement séparées dans l'état de contraction. Corps lisse, luisant. Antennes assez longues, pouvant atteindre (ou presque) le bord postérieur du troisième segment. Chaperon ayant son bord inférieur cilié, subéchancré. Au dessus de ce bord est un sillon angulaire, qu'on prendrait volontiers pour l'échancrure du chaperon, ou seulement un espace rugueux; et sur les angles latéro supérieurs on voit une bosselure oblique en forme de bourrelet, placée en dehors de l'insertion de chaque antenne. Front partagé par un sillon simple. Corps déprimé, moins haut que large (même sans les carènes). Dos médiocrement convexe (transversalement). Surface dorsale des anneaux, luisante, finement plissée, mais les carènes assez fortement burinées, surtout dans la portion antérieure du corps. La ligne de séparation de la portion cylindrique de chaque segment et de sa portion carénifère offrant une zone de petites stries longitudinales visibles à la loupe. Premier segment un peu moins large que le deuxième; ses lobes latéraux larges et arrondis. Segments suivants ayant tous leurs carènes tronqueés à angle droit, bordées antérieurement par un petit cordon et latéralement par un bourrelet saillant qui en occupe toute la longueur. Bord antérieur des carènes faiblement arqué et se terminant par une trés-petite dent, placée en avant du bourrelet latéral. Bord postérieur des anneaux légèrement concave, surtout dans la partie postérieure du corps, où l'angle postérieure des carènes est prolongé en arrière. Segment préanal en palmette subquadrangulaire, tronqué postérieurement. Plaque sous-anale arondie. Valves anales lisses, offrant pres du bord un sillon prononcé. Pores répugnatoires tout à fait latéraux et trés-petits.

Couleur de l'animal dessèche, d'un gris-blanc de porcelaine, ou cendrée, avec une tache couleur de chair au milieu du bord postérieur de chaque segment. Carènes surtout leurs angles postérieurs et le bout du dernier segment, ainsi que le bord antérieur du premier, couleur de chair. Dessous du corps, pattes, antennes et front, fauves ou de couleur pâle. Vivant, l'animal a sans doute une couleur brune. Longueur $0^{m},030$; largeur 0,0045.

♂. Plus aplati que la femelle; le premier segment aussi large que le deuxième; les carènes plus relevées, horizontales; leur triangle postérieur plat et lamelleux.

Habite. La Caroline du Sud."

P. HISPIDIPES.

P. olivaceo-brunneus, immaculatus; scuto anale triangulare piloso, apice truncato et decurvato; pedibus hispidis; appendicibus masculis brevibus, robustis, spina terminale modica, ultima abrupte curvata, dense pilosa. (Fig. 48.)

Olive-brown, immaculate; anal scutum triangular, with long hairs; apex truncate and decurvate; feet roughly hairy; male appendages short, robust; their terminal spine moderate, distally abruptly curvate, densely pilose.

P. HISPIDIPES, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 7.

Fig. 48.



The side plates are rather short, with their edges much thickened. The head has its vertex strongly canaliculate. Its anterior face is marked with two small punctiform impressions. The lower border is not very strongly emarginate, and is set with a fringe of short thick hairs. The antennæ are mostly dark-colored, scarcely at all clavate, and coarsely pubescent. The feet are rough, with closely set, stiff hairs. The anal scutum is prolonged posteriorly, so as to come almost to a blunt point. The appendages in the male are short and thick. Their terminal spine is slightly curved at its base, thence is nearly straight, save at its distal extremity, where it is abruptly curved, becoming nearly horizontal. It is beset with very numerous long hairs. I have examined them in eighteen specimens, and found them to agree perfectly. The female appendages consist of a pair of short, conoidal, very pilose processes, which have an opening along their inner edge. Length, 1⅛ inches.

Hab. Illinois.—Smithsonian Collection. R. Kennicott.

Var. ? P. læte castaneus, fulvo vel rubro maculatus, linea nigra dorsali ornatus; laminis lateralibus marginibus rubris vel fulvis.

Var. ? Bright chestnut, maculate with red or yellow, ornamented with a black dorsal line; margins of the lateral laminæ red or yellowish.

Wood, Proc. Acad. Nat. Sci., 1864, p. 8.

This is possibly a distinct species, but as I have seen but a very few individuals, and the male genital appendages do not differ from those of *P. hispidipes*, I prefer not risking a synonym. Whether the spots are yellowish or red in the living animal, the length of time the specimens have been preserved in alcohol precludes me from deciding.

The spots are sometimes arranged regularly—two large ones on each side of the mesial line, and a row of small ones on the posterior border.

Hab. Illinois.—Smithsonian Collection. R. Kennicott.

Subgenus FONTARIA.

Dorsum convexum. Laminæ laterales magnæ, depressæ.

Dorsum convex. Lateral laminæ large, depressed.

P. Virginiensis.

P. castaneus; laminis lateralibus fulvis; appendicibus masculis maximis, spinulo gracile basale armato; spina terminale breve, robusta, curvata, bifida. (Fig. 49.)

Chestnut, with yellowish lateral laminæ; male appendages large, armed with a slender basal spinule, their terminal spine short, robust, curved, bifid.

Iulus Virginiensis, *Drury*, Ins. Exotica.
Polyd. Virginiensis, *Pal. Beavois.* Ins. á Afr. et Amer. Apteres, pl. iv, fig. 5.
" " *Say*, Journ. Acad. Nat. Sci., 1st series, vol. ii.
" " *Gervais*, Ann. Sc. Nat., 2d serie, t. vii, p. 43; et Exped. Suit. a Buffon, Apteres, vol. iv, p. 106; et Exped. L'Ameriq. du Sud (Castelneau), Myriapoda, p. 6.
" " *Newport*, Catal. Brit. Mus.
Fontaria Virginiensis, *J. E. Gray*, Griffith's Animal Kingdom Insecta, pl. 135, fig. 1.
Vix Polyd. Virginiensis, *H. De Saussure*, Memoir Soc. Hist. Nat. Geneva, tome xv, p. 320.

The color of this species is a dark reddish chestnut, with the lateral laminæ of bright yellow, sometimes verging towards orange. The under surface of the body is yellowish. The scuta are wrinkled as in P. corrugatus, but not to so great an extent, at least in the individuals that have fallen under my observation. The head is of the same color as the body; its vertex furrow is strongly pronounced; its anterior margin yellowish and broadly emarginate. The antennæ are lightish chestnut, and distally very pilose, almost pubescent. The posterior scutum is triangular, with its apex truncate; its color is that of the lateral laminæ. The latter have their anterior angles somewhat rounded, their posterior moderately acute, rarely prolonged except in the last four or five. The male appendages are large and robust; from each of the pair springs a small falciform spine, lying so close as not to be easily perceived. The terminal spine is set at an angle to the main process. Its base is very hairy, and has springing from it a long slender spinule. Distally the spine is bifid and curiously curved. [The figure represents only the terminal spine.] I have no specimens to enable me to describe the female appendages.

Fig. 49.



In some individuals there exists a well-pronounced black, median, dorsal line. In others the pattern of coloration approximates that of P. corrugatus; but I have never seen a well-pronounced margination of the scuta. There may be some doubt as to whether this is the species intended to be indicated in the original description of P. Virginiensis, which

would apply probably equally well to several species. In the absence of any type, it has seemed better to apply the name somewhat empirically, rather than to discard it altogether.

As far as I can determine, P. Virginiensis of Saussure is not the species here recognized, but represents rather the two species trimaculatus and corrugatus combined, both of which he appears to have had.

Hab. Middle States.

P. CORRUGATUS.

P. atro-castaneus, scutis fulvo postice marginatis; laminis lateralibus fulvis, latissimis; scuto anale triangulare, elongato, postico fulvo, apice truncato; appendicibus masculis maximis, spinulo laterale robusto subbreve vix curvato armatis; spina terminale maxima, robusta, compressa, tortuosa, spinulo basale armata. (Fig. 50.)

Blackish-chestnut; scuta margined with fulvous posteriorly; lateral laminæ yellowish, very broad; anal scutum triangular, elongate, posteriorly yellowish; its apex truncate; male appendages very large, armed with a rather short, robust, scarcely curved, lateral spinule; terminal spine very large, robust, compressed, tortuous, armed with a basal spinule.

P. CORRUGATUS, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 6.

The color of the perfect animal is a chestnut-black, rarely reddish chestnut, with a moderately broad margin of fulvous [in alcoholic specimens] on each scutum. This band may be *red* during life. The scutæ beautifully polished to the naked eye, the microscope shows to be obsoletely wrinkled. Very many of these wrinkles are longitudinal. The head is of the same color as the body; medianly it is distinctly sulcate; inferiorly it is broadly and rather deeply emarginate. The scutal side plates are fulvous above and below. Their anterior angles are rounded, their posterior more or less acute, and in the hinder ones prolonged. The under surface of the body is of a light yellow. The male genital appendages are very large and robust. They have a short, slightly crooked spinule attached and lying close to their side. The terminal spine is irregularly spiral, and has near its base a curved spinule. At the point of its origin is a tuft of bristly hairs. Each female appendage (Fig. 51) is chiefly composed of a short, almost globular, scarcely at all pilose process, in one side of which there exists a large opening. Through the side opening projects a pair of large, thick plates, fitting together somewhat in the manner of bivalve shells. These nearly equal in height the main process. The spine on the second joint of the feet is robust, but acute. The whole animal is about one and a half inches in length.

Fig. 50.



Fig. 51.



Hab. Michigan.—Prof. Miles.—Trenton Falls, New York. Mus. Comp. Zoology.—D. Mack.

P. BIFIDUS.

P. rubro castaneus, segmentis et antice et postice late fulvo-marginatis, laminis lateralibus dilute fulvis; scuto anale triangulare, apice truncato et decurvato; appendicibus masculis, elongatis, pilosis; spina terminale gracillima, proxima cylindracea, ultima bifida et nonnihil abrupte curvata, spinulo basale gracillimo parvo armata.

Reddish-chestnut; segments both anteriorly and posteriorly broadly margined with yellowish; lateral laminæ dilute yellow; anal scutum triangular, its apex truncate and decurvate; male appendages elongate, pilose; their terminal spine very slender, proximally cylindrical, distally bifid, and somewhat abruptly curved, armed with a small, very slender basal spine.

P. BIFIDUS, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 7.

All of my specimens have been preserved for a length of time in alcohol, so that the description of color is not as accurate as it should be. The anterior aspect of the head is much lighter than the vertex, which is medianly strongly canaliculate. The antennæ are dilute fulvous, rather longer than in *P. Virginiensis*, and distally, sparsely and shortly pilose. The spinules on the distal ends of the first and second joints of the long and slender feet are robust, but are often obsolete anteriorly. The terminal scutum has several punctæ closely resembling pores. The preanal scale is triangular; it has two little elevations surmounted by a punctum. The male appendages (Fig. 52) are elongate. Their terminal spine is very slender and cylindrical in its proximal portion; distally it is bifid and strongly curved. It is ornamented with a very slender curved basal spinule.

Fig. 52.



Hab. Georgia. Museum of Comp. Zoology.—Dr. Le Conte. Texas. Smithsonian Collection.—G. Wurdeman.

P. TRIMACULATUS.

P. saturate rubro-brunneus; scutis postice fulvo trimaculatis, corrugatis; antennis ultimis pilosis; appendicibus masculis maximis, crassis, ultimis obtuse rotundatis, spina terminali gracillima, enormiter convoluta. (Fig. 53.)

Deep reddish-brown; scuta posteriorly trimaculate with yellow, corrugate; antennæ distally pilose; male appendages very large, thick, distally obtusely rounded; terminal spine slender, irregularly convolute.

P. TRIMACULATUS, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 6.

The color of this species is a dark reddish-brown. Each scutum has on the posterior

portion of its lateral lamina a bright yellow or orange spot, and a blotch of the same tint on the median portion of its posterior border. Occasionally this is so prolonged as almost to give the idea of a continuous transverse band. The first scutum has two central markings, situated the one on its anterior, and the other on its posterior border. These are so shaped and joined together as to suggest the idea of an hour-glass. The anal scutum is triangular and somewhat elongate. It is yellow, but has a dark spot on each side, and its truncate apex is tipped with brown. The head is chestnut-brown. Its vertex is deeply canaliculate, and its inferior lip distinctly emarginate and fringed with hairs. The antennæ are light-brown, slender, and not at all clavate. The feet are light-yellow, with their distal portion somewhat pilose and occasionally tipped with brown. The male genital appendages (Fig. 53) are very large and robust. Their terminal spine is simple, long, slender, and irregularly bent upon itself. They are also furnished with a small, nearly straight, spinule, placed proximally as to the terminal. The female appendages (Fig. 54) are short, thick, and bulbous. On one side of each there is an opening, with two projecting plates separated from one another by a linear orifice. I have seen a male and female, which were collected by Mr. E. D. Cope in Susquehanna County, Pennsylvania. They are about two inches long.

Fig. 53.



Fig. 54.



P. CRASSICUTIS.

P. maximus, robustus; scutis enormiter subrude punctatis; appendicibus masculis (Fig. 55), singula spinis quatuor, duobus magnis, parvis duobus armata.

Very large, robust; scuta irregularly, subrudely punctate; male appendages each armed with four spines; two large, two small.

P. CRASSICUTIS, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 7.

The color of all the specimens is light-testaceous, with, in many, a dark dorsal line. It is very possible that the alcohol, in which they have been long preserved, may have destroyed the original color. The animal is very large and robust, and has its outer armor and side plates very heavy. The head on its upper surface has a distinct median furrow, and on its lower a broadly linear, oblique depression on each side. The inferior margin is rather broadly and deeply emarginate. The lateral laminæ are rather short. The female appendages (Fig. 40) are a pair of small, pyramidal, pilose bodies, whose apices are split into three or four very minute mameloid processes. The male organs are

Fig. 55.



large, and distally very hairy. They are each armed with two large and two small spines. The longer and more slender of the former at its proximal portion is bent rather abruptly at right angles to itself, but is nearly straight afterwards. The more robust is nearly straight, save at its distal extremity, where it is abruptly bent at right angles to itself. It is armed with several very slender spinules, and has one edge distantly and obsoletely denticulate. Of the smaller spines, one is short and blunt; the other much longer, sharp, slender, and falciform. The last scutum is triangular, and has its apex truncate and very slightly decurvate. The preanal scale is semi-orbicular. Length, 2 to 3 inches.

Hab. Mississippi.—Museum of Smithsonian.

Subgenus LEPTODESMUS.

Corpus subcylindricum. Dorsum valde convexum. Laminæ laterales parvæ.

Body subcylindrical. Dorsum very convex. Lateral laminæ small.

P. placidus.

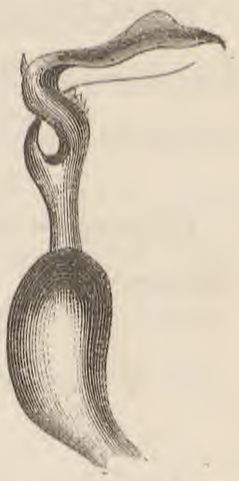
P. olivaceo-brunneus, scutis plerumque nigro vittatis; laminis lateralibus parvis, dilute brunneis; pedibus saturate olivaceis; sternis dilute brunneis; appendicibus (Fig. 56) masculis, valde elongatis; spina terminale magna, in spiram ducta et spinulo basali longissimo falciforme et altero laterale breve robusto instructa, margine partim acute serrato, partim integro.

Olive-brown; many of the scuta banded with black; lateral laminæ small, light-brown; sterna light-brown; male appendages strongly elongate; terminal spine large, spiral, furnished with a very long, falciform, basal spinule, and a second short, robust, lateral one; its margin partly entire, partly acutely serrulate.

P. placidus, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 9.

The head is dark-colored. Besides its median furrow, it is ornamented with a pair of sometimes illy pronounced puncta on each side of the vertex. Its inferior border is rather broadly emarginate. The antennæ are elongate, dark-brown, and tipped with black. The anal scutum agrees with the others in color. It is triangular, with its apex truncate, obscurely emarginate and decurvate. The male genital appendages are strikingly elongate. The terminal spine is nearly black. It is bent spirally on itself, but after performing a little more than an entire turn is nearly horizontal for some length. It is flattened, with its superior surface somewhat umbonate, and ends in a thick, blunt, spine-like process. The proximal portion of the anterior margin is acutely serrate. From the edge projects a short thorn-like spinule, and from the base a long, slender, falciform spine. Length, 1¼ inches.

Fig. 56.



Hab. Michigan.—Prof. Miles.

P. FLORIDUS (Var. ?).

P. atro-castaneus; scutis postice rubro-aurantiaco marginatis; laminis lateralibus parvis, læte rubro-aurantiacis; appendicibus masculis *P. placidi* illis similibus.

Blackish-chestnut; scuto posteriorly marginate with reddish orange; lateral laminæ small, bright reddish orange; male appendages like those of *P. placidus*.

P. FLORIDUS (Var. ?), *Wood*, Proc. Acad. Nat. Sci., 1864, p. 9.

The head is lighter colored than the body. It is medianly canaliculate, with a pair of punctations on each side of its vertex. Its inferior border is broadly emarginate. The antennæ are rather long and slender, very slightly clavate, light-brown, and distally tipped with black. The scuta are smooth, beautifully polished, and not corrugate. The side plates are distant, quite small, and nearly horizontal, with their anterior angles rounded. The anal scutum is prolonged, and is sometimes wholly, sometimes partially, orange. It is triangular, with its truncate, decurvate, slightly emarginate apex projecting much beyond the anal scales. The feet are cylindrical, yellow, and somewhat pilose. The male appendages resemble those of *P. placidus*, except in color. They are yellowish. Those of the female consist of a pair of short, blunt processes. Each of these has a basal portion into which is set a short, somewhat flattened body, with an obscure linear opening traversing its distal surface. From the junction of these two parts springs a heavy fringe of long, coarse hair. *P. floridus* is very possibly a distinct species from *P. placidus*. I have seen but a single individual of the latter. The general appearance of the two is so dissimilar as to incline me to the belief of their distinctness; but they agree well as to their genitalia, and a suite of specimens might show their identity. Length, 1¼ inches.

Hab. Michigan.—Prof. Miles.

P. HAYDENIANUS.

P. olivaceo-castaneus; antennis modicis, sparse pilosis, ultimis nigris; laminis lateralibus luteis; appendicibus masculis hirsutis et processu lato breve et spinis duabus armatis; spina terminale (Fig. 57), modice robusta, valde curvata.

Olive-chestnut; antennæ moderate, sparsely pilose, distally black; lateral laminæ yellowish; male appendages hirsute, armed with a broad, short process and two spines; terminal spine moderately robust, strongly curved.

P. HAYDENIANUS, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 10.

Judging from an alcoholic specimen, the color of this animal is an olive-chestnut, with the side plates yellowish, and the posterior portions of the scuta much lighter than the

anterior. The head is bright-chestnut, and is ornamented with a median furrow on its vertex, and a pair of impressed dots on each side of its face. Its inferior border is medianly moderately emarginate. The margins of the side plates are somewhat thickened. The anal scutum is yellowish, small, subtriangular, and distinctly emarginate posteriorly. The feet are very slender, and are shortly pilose. The femora of the hinder ones are armed each with a small spine on their distal extremity. The small male appendages are hairy at the base. They are armed with a broad, obtuse, spinous process, and a slender curved spine besides the terminal. The latter is robust, and is bent with a double curve, that is, anteriorly and laterally. I have dedicated this species to my friend, Dr. Hayden, whose name is inseparably connected with the natural history of the Far West.

Fig. 57.



Hab. Oregon.—Museum of the Smithsonian.

Subgenus STRONGYLOSOMA.

Corpus cylindricum. Laminæ laterales subnullæ.

Body cylindrical. Lateral laminæ very small.

P. ERUCA.

P. brunneus? robustus; antennis brevibus, pilosis, haud clavatis; scutis subrude punctatis; pedibus parvis, gracilibus, modice hirsutis.

Brown? robust; antennæ short, pilose, not clavate; scuta subrudely punctate; feet small, slender, moderately hirsute.

P. ERUCA, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 8.

Judging from the badly preserved alcoholic specimens, the color of this species is reddish-brown, with the side plates a lighter color. The body is very robust. The head has a median furrow on its vertex, and its lower border emarginate. The side plates, excepting the posterior, which are better pronounced, have but the posterior angles, which are acute. The scuta appear to have a narrow edging of black posteriorly. The terminal scutum is subtriangular, very prolonged and very thick posteriorly. I have never had an opportunity of examining the male organs. Those of the female are very pilose, and are formed of two portions. They are contracted at their bases, and expanded above, somewhat as a reversed flattened cone. The basal piece is thicker and less hairy than the other. The distal piece is set into it, and has an opening along the free extremity.

Hab. Oregon.—Museum of the Smithsonian.

Fam. POLYXENIDÆ, *Newport.*

"Caput arcuatum, prominens. Corpus latum. Pedes attenuati; coxis maximis. Segmentum anale fasciculis longis."

Head arcuate, prominent. Body broad. Feet attenuate, with very large coxæ. Anal segment with long fasciculi.

As I have never seen a specimen of this family, the characters of it and the genus are those given by Mr. Newport, Philos. Trans., vol. xix, p. 277.

Gen. POLYXENUS, *Latreille.*

"Corpus breve, squamis parvis penicillatis vestitum. Pedum paria 13."

Body short, clothed with small penicillate scales. Pairs of feet 13.

P. FASCICULATUS.

"Body pale-brown, linear, incisures ciliated, fasciculated each side; head deeply ciliated before. Segments smooth, ciliate at the incisures, and fasciculate with brown setæ each side; terminal pencil cinereous; head semi-orbicular, depressed, deeply and densely ciliated on the edge with setæ; eyes small, oval, prominent, placed obliquely in the middle of the lateral margin; antennæ very short, thick, reddish-brown; feet white. Length rather more than the one-tenth of an inch."

"Inhabits the Southern States."

Say, Journ. A. N. S., 1st series, vol. ii, p. 108.

Sub Ord. SUGENTIA.*

Caput parvissimum, conicum. Os elongatum, tubulatum. (Figs. 58, 59.)

Head very small, conical. Mouth elongate, tubular.

In the Sugentia the head is very small, and is so placed as to be almost entirely concealed beneath the broad anterior scuta. The parts around the mouth are so fused together as to make a conical beak of greater or less length, suitable only for the imbibition of liquid food. The eyes may be present or absent. The antennæ are formed according to the type of the Diplopoda, with seven joints. The body is composed of numerous segments. The scuta may be prolonged laterally into laminæ, but afford protection only to the back and flanks; the central part of the abdomen is not covered by a firm,

* Order Sugentia, Brandt, Recueil.

resistant shell. The feet are hidden beneath the broad body. The male genitalia are placed in the seventh segment. In the classification of the families and genera I have followed Mr. Brandt,* his arrangement, as far as the two species I have seen enable me to judge, being founded on natural characters.

He adopts two families, which are characterized by the presence and absence of eyes. Though this would of itself scarcely seem to be sufficient to separate groups of such rank, yet, as it is associated with many differences in form &c., it serves as the most tangible distinguishing mark.

This suborder seems to stand at the bottom of the Myriapoda. In external appearance and form it approaches most nearly to the Vermes, and has undoubtedly the lowest structural development.

Fam. POLYZONIDÆ.

"Oculi parvi, simplices, in media fronte inter antennes conspicui."†

Eyes small, simple, conspicuous in the middle of the anterior surface of the head between the antennæ.

Mr. Brandt described this family under the name of Ommatophora, and the following under the name of Typhlogena; but I have adopted the names of Polyzonidæ and Siphonophoridæ of Newport, for the reason that the former are not consistent with the laws of modern scientific nomenclature.

Genus OCTOGLENA.‡

Oculi octo, in seriebus duabus simplicibus dispositi. (Fig. 59.)

Eyes eight, arranged in two simple series.

The eyes in this genus are very prominent, and are arranged in two straight rows, which are so placed, one on each side near the base of the antennæ, as to be convergent inferiorly.

O. BIVIRGATA.

O. brunnea, utrinque virga fusca ornata; segmentis fere 45.

Brown, with a fuscous stripe on each side; segments about 45.

O. BIVIRGATA, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 186.

* Recueil De Mem., p. 49.

† Brandt, *loc. cit.*

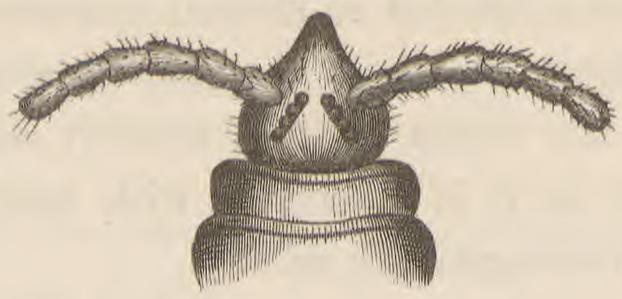
‡ Wood, Proc. Acad. Nat. Sci., 1864, p. 186. $\gamma\lambda o\eta$, oculus.

The head of this species is very small, and is pilose. The antennæ are rather heavy, and are very pilose. The eyes are large and very prominent. The dorsum is slightly

Fig. 58.



Fig. 59.



convex, and is ornamented on each side by a broad fuscous stripe, which is intersected by numerous, indistinct, dark lines.

The scuta are very smooth, and have no distinct lateral plates, but their edges are rather thin and strongly elevated. The penultimate scutum is much broader than its neighbors. The last scutum is very small. The feet are dark-colored. There are two or three specimens in the possession of the Academy, which, I believe, were collected by Dr. John L. Le Conte, U. S. A., in the mountains of Georgia. Fig. 58 represents the under, Fig. 59 the upper surface of the head.

Fam. SIPHONOPHORIDÆ.

Oculi nulli.

Eyes none.

Genus BRACHYCYBE.*

Rostrum acutum, brevissimum, antennis multo brevius. (Fig. 60.)

Rostrum acute, very short, much shorter than the antennæ.

I have never studied the allied genus *Siphonophora* of Brandt, but, if the characters relied on by that author are at all generic, there can be no doubt that the American species belongs to a distinct genus. In *Siphonophora* the rostrum or mouth is very much elongated, and approaches the antennæ in length. In *Brachycybe* the latter are several times the longer.

B. Le Contii.

Fulvo-brunneus? dorso modice convexo, medio leviter canaliculato; antennis parvis, filiformibus, pilosis; scutorum superficie asperata, obscure transverse canaliculata; scuto postremo postice spinæ obtusæ serie instructo; laminis lateralibus longis, angustis, vix sejunctis; segmentis 47; pedibus breve pilosis.

* *Wood*, Proc. Acad. Nat. Sci., 1864, p. 187. Βραχυς, brevis. Κυβος, rostrum.

Yellowish-brown ?; dorsum moderately convex, medianly lightly canaliculate; antennæ small, filiform, pilose; surface of the scuta rough, obscurely transversely canaliculate; last scutum furnished posteriorly with a series of obtuse spines; lateral laminæ long, narrow, scarcely separated; segments 47; feet shortly pilose.

B. Le Contii, *Wood*, Proc. Acad. Nat. Sci., 1864, p. 187.

In our specimens, which have been preserved for a long time in alcohol, the color is a light yellowish-brown. The anterior scuta are tuberculate, the posterior merely roughened.

Fig. 60.

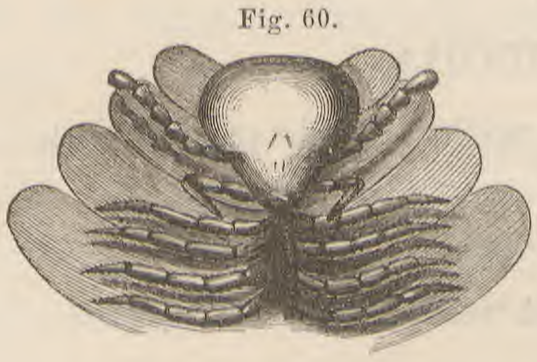
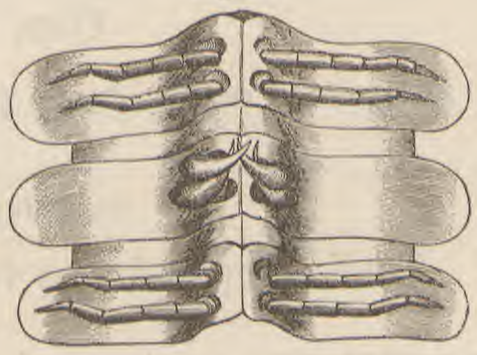


Fig. 61.



Each has a more or less obsolete transverse groove extending all across the lateral laminæ. The latter are very long and narrow; they are placed very close together, and are often bent slightly backwards. Their external margin is somewhat oblique, and is furnished in all except, perhaps, the most anterior, with a pore. The small feet are entirely concealed beneath the broad body. The male appendages (Fig. 61) consist of two pairs of acute feet-like processes. It affords me much pleasure to dedicate this species to Medical Inspector John L. Le Conte, U. S. A., as an acknowledgment of the many assistances which he has afforded me in the prosecution of my studies.

Hab. Georgia.—Collection of the Acad.———Mus. Comp. Zoology. Dr. John L. Le Conte, U. S. A.

SYNOPSIS OF NORTH AMERICAN MYRIAPODA.

Class Myriapoda.

Ord. CHILOPODA.

Segments of the body provided with a single pair of feet.

Sub Ord. SCHIZOTARSIA.

Tarsi composed of a very great number of small joints.

Fam. CERMATIIDÆ.

Gen. Cermatia.

C. forceps.

Sub Ord. HOLOTARSIA.

Tarsi composed of but few joints.

Fam. LITHOBIIDÆ.

Dorsal scuta 15, two sets; a smaller scutum alternating with a larger.

Gen. Lithobius.

Excavations on the posterior coxæ large, ovate, arranged in a single series upon a depressed face.

L. Americanus. Scuta smooth, not rugose. Labial denticules about 10.
L. planus.† Scuta rugose. Labial denticules about 14.
L. paucidens. Labial denticules about 4.

Gen. Bothropolys.

Excavations on the posterior coxæ small, almost round; arranged in a three or four-fold series on a scarcely depressed face.

B. multidentatus. Ocelli on each side from 32—37.
B. Xanti. Ocelli on each side 18. Surface of the scuta very roughly rugose.
B. bipunctatus. Ocelli on each side 18. Surface of the scuta but slightly roughened.

† Species marked with a cross have never been identified by the author.

FAM. SCOLOPENDRIDÆ.

Feet-bearing segments 21—23.

GEN. SCOLOPENDRA.

Cephalic segment imbricate. Pairs of feet 21. Eyes 4 on each side.

Antennæ more than 20 *articulate.*

S. heros. Brownish. Antennæ 25 articulate. Basal joint of the last pair of legs with 5—7 spines on the inner surface; 7—10 on the lower, arranged in a threefold series. Length, 6 inches.

Var. castaneiceps. Green, with the head and appendages bright reddish-chestnut.

S. polymorpha. Brownish. Antennæ 30 articulate. Basal joint of last pair of legs with 3—7 spines on inner surface; 10—18 on the lower, arranged in a fourfold series. Length, 4 inches.

S. viridis. Greenish. Antennæ 23 articulate. Basal joint of last pair of legs with 2—5 spines on inner surface, 7—12 on the lower. Length, 2½ inches.

S. Copeana. Yellowish-chestnut, sprinkled with green. Antennæ 25 articulate. Basal joint of last pair of feet very slightly longer than the tibial, with 4—6 spines on the inner surface, 9—17 on the lower. Length, 4 inches.

Antennæ not more than 20 *articulate.*

S. inæquidens. Greenish. Antennæ 17 articulate. Basal joint of last pair of legs with 3—8 spines on the inner surface, 7—10 on the lower. Length, 4 inches.

S. byssina. Greenish or brownish. Antennæ 18 articulate. Basal joint of last pair of legs longer than the tibial, with 2—3 spines on its inner surface.

S. bispinipes. Olivaceous. Antennæ 19 articulate. Basal and tibial joints of last pair of legs about equal in length; basal bispinous.

S. longipes. Chestnut. Antennæ 17 articulate. Last pair of feet very long, with 30—50 spines apiece. Length, 5 inches.

S. morsitans. Brownish. Antennæ 20 articulate. Basal joint of last pair of legs with its superior margins strongly elevated; inner surface with 5 spines; lower 7—9, arranged in a threefold, alternating series.

GEN. CRYPTOPS.

Feet-bearing segments 21. Eyes none. Last scutum as in Scolopendra.

C. hyalina.†

C. Milbertii.†

GEN. OPISTHEMEGA.

Opisthemega. Feet-bearing segments 21. Eyes none. Last scutum the largest.

O. postica. Basal joint of last pair of feet not armed with a spine, and its margins not serrulate.

O. spinicauda. Basal joint of last pair of feet armed with a spine, and its inner margins serrulate.

GEN. THEATOPS.

"Eyes distinct. Feet-bearing segments 21. Joints of the last pair of feet obconic, large, abbreviate."

T. postica.†

GEN. SCOLOPOCRYPTOPS.

Eyes none. Feet-bearing segments 23.

Margin of the labium nearly straight.

S. sexspinosa. Scuta not rugose. Lateral anal appendages with a very minute rudimentary spinule on their supero-posterior angle.

S. spinicauda. Scuta somewhat rugose. Lateral anal appendages with a well-pronounced, black spinule on their supero-posterior angle.

Margin of the labium shaped like an inverted w.

S. gracilis. Basal joint of last pair of feet longer than the tibial; the three last joints only pubescent. Lateral anal appendages elongate.

S. lanatipes. Basal and tibial joints of last pair of feet about equal. Tibial, tarsal, and metatarsal joints roughly pubescent. Lateral anal appendages short.

FAM. GEOPHILIDÆ.

Anterior subsegment of each segment not completely atrophied. Segments very numerous. Antennæ 14 articulate.

GEN. MECISTOCEPHALUS.

Cephalic segment elongate, narrow, more than twice longer than broad. Prebasal segment separate. Basal and subbasal segments coalescent.

M. fulvus. Fulvous. Head light orange. Cephalic segment rapidly contracted and rounded off at its posterior end. Pairs of feet 57.

M. limatus. Orange? Head deep red. Cephalic segment regularly narrowed from the front. Pairs of feet 43—44.

M. melanonotus. Light orange, with two broad, irregular, blackish bands, from the head to the penultimate segment, involving nearly the whole dorsum. Pairs of feet about 50.

GEN. GEOPHILUS.

Cephalic segment subquadrate. Prebasal segment coalesced with the basal. Posterior margin of the basal segment much longer than anterior.

G. cephalicus. Anterior portion of the body obscurely orange; the posterior olivaceous. Feet 48 pairs.

Var. ?—Feet 51 pairs.

G. lævis. Orange; with a double, blackish, anteriorly obsolete, dorsal line, terminating rather abruptly at the penultimate segment. Feet 53 pairs.

G. brevicornis. Deep orange. Cephalic segment small, sparsely subprofoundly punctate. Antennæ rather short. Pairs of feet 55.

G. bipuncticeps. Orange. Cephalic segment large, copiously profoundly punctate. Antennæ rather long. Feet 61—63 pairs.

GEN. STRIGAMIA.

Cephalic segment small, generally subtriangulâr, narrowed anteriorly. Body anteriorly attenuate.

Coxæ of last pair of legs impressed with little pits.

S. bothriopus. Bright red. Pairs of feet 50.

S. Walkeri. Orange. Pairs of feet 64.

S. bidens. Orange. Pairs of feet 76.

Coxæ of last pairs of feet not pitted.

S. fulva. Pairs of feet 47. Cephalic segment subtriangular.

S. chionophila. Pairs of feet 43. Cephalic segment subquadrate, medianly canaliculate.

S. lævipes. Pairs of feet 69. Head rather large.

S. parviceps. Pairs of feet 71. Head small, impunctate.

S. cephalica. Pairs of feet 75. Head large, impunctate.

S. maculaticeps. Pairs of feet 77. Head obscurely red and minutely maculate with white, rather small.

S. laticeps. Pairs of feet 81. Head large, impunctate. Length, 3 inches.

S. epileptica. Pairs of feet 81. Head rather small, minutely maculate with white. Length, $5\frac{1}{2}$ inches.

S. tæniopsis. Pairs of feet 141.

S. rubens.† Pairs of feet 50.

S. Whitei.† Pairs of feet 76.

Ord. II. DIPLOPODA.

Each fully developed segment of the body provided with two pairs of feet.

Sub Ord. STRONGYLIA.

Mouth furnished with jaws suitable for the mastication of vegetable matters.

Fam. POLYDESMIDÆ.

Sternum and scutum of each segment fused together into a complete ring. Body composed of few segments; each furnished with lateral laminæ.

Gen. Polydesmus.

Lateral pores on the 5—7—9—10—12—13—15—16—17—18—19 scuta.

Subgenus Polydesmus.

Dorsum complanate. Lateral laminæ large, horizontal.

*P. setiger.** Scuta with minute, obtuse, tuberculoid scales (sometimes obsolete) with a row of acute, conical, seta-tipped tubercles along the posterior border.

*P. granulatus.** Scuta covered with convex, obtuse, tuberculoid scales, arranged in four more or less irregular transverse series; none of them seta-tipped.

P. hispidus.† Scuta with scales in five series.

P. serratus. Scuta with 9—10 complanate scales, arranged in two series, besides a third obsolete series.

P. Canadensis. Color brown. Scuta with 8 scales, arranged in two series.

P. cerasinus. Color cherry-red. Scuta like in *P. Canadensis.*

Subgenus Paradesmus.

Dorsum moderately convex. Lateral laminæ large, horizontal.

P. erythropygus. Olive-chestnut; scuta with a large orange spot on their posterior surface. Lateral laminæ orange. Anal scutum broad, prolonged.

P. hispidipes. Olive-brown, immaculate. Anal scutum triangular.

Var.? Ornamented with small orange spots. Lateral laminæ orange.

Subgenus Fontaria.

Dorsum convex. Lateral laminæ large, depressed.

P. Virginiensis. Chestnut, with yellowish lateral laminæ.

* Probably these two species belong to a new genus.

P. corrugatus. Blackish chestnut, with yellowish lateral laminæ, and the scuta posteriorly margined with yellow.

P. bifidus. Reddish chestnut, with yellowish lateral laminæ and the scuta both anteriorly and posteriorly margined with yellow.

P. trimaculatus. Deep reddish brown, with three bright orange spots on each scutum.

P. crassicutis. Very large. Scuta irregularly subrudely punctate.

Subgenus Leptodesmus.

Dorsum strongly convex. Lateral laminæ small.

P. placidus. Olive brown. Scuta banded with black. Lateral laminæ light brown.

P. floridus. Blackish chestnut; scuta margined posteriorly with reddish orange. Lateral laminæ orange.

P. Haydenianus. Olive chestnut. Lateral laminæ yellowish.

Subgenus Strongylosoma.

Body cylindrical. Lateral laminæ very small.

P. eruca.

Fam. IULIDÆ.

Posterior subsegments, with their sterna atrophied. Segments numerous, without lateral laminæ.

Genus Iulus.

The second scutum not produced anteriorly at the sides so as to abut against the head.

a. Last scutum mucronate.

* *Mucro small.*

I. impressus. Reddish chestnut. Segments 52. Scuta scarcely at all pilose.

I. pilosiscuta. Brownish chestnut. Segments 58. Scuta very pilose.

I. Oregonensis. Bright chestnut. Segments 45. Scuta scarcely at all pilose.

** *Mucro large.*

† *Mucro uncinate.*

I. Canadensis. Brightish chestnut, with a black dorsal stripe and series of black dots on each side. Segments 53. Mucro very large.

I. immaculatus. Dark reddish brown, immaculate. Segments 51. Mucro moderate.

†† *Mucro straight, or nearly so.*

I. Pennsylvanicus. Segments 63. Scuta on the upper surface distantly and obsoletely canaliculate.

I. canaliculatus. Segments 51. Scuta on the upper surface closely and deeply canaliculate, and furnished with a ring of distant long hairs.

I. laqueatus. Segments 49. Scuta on the upper surface closely and deeply canaliculate, but not furnished with a ring of hairs.

I. exiguus.† Segments 33.

b. Last scutum not mucronate.

I. cinerefrons. Brownish, annulate with ash color. Scuta with their upper surface smooth. Segments 34 ?—45 ?.

I. Milesii. Deep brown. Upper surface of scuta nearly smooth; lower surface closely and deeply canaliculate. Segments 33.

I. cærulo-cinctus. Brown, annulate with bluish rings. The surface of the scuta regularly but rather distantly canaliculate. Segments 42.

I. hortensis. Brownish, with series of strongly pronounced black dots on each side. Segments 42. Scuta closely canaliculate above and below.

I. virgatus. Deep brown, with the dorsum luteous, and ornamented with a black median line. Segments 35. Scuta closely canaliculate above and below.

I. minutus.†

I. stigmatosus.†

GEN. SPIROBOLUS. Second scutum produced forwards at the sides so as to abut against the head.

Upper surface of scuta not canaliculate.

S. marginatus. Brown, with reddish annuli. Head very abundantly punctate. Segments 53—57.

S. uncigerus. Brown, with reddish annuli. Head rather sparsely punctate. Segments 50—53.

S. spinigerus. Fulvous, with very large greenish maculæ. Segments 48.

Upper surface of scuta canaliculate.

S. angusticeps.

FAM. LYSIOPETALIDÆ.

Sterna atrophied, not coalescent with or united by suture to the scuta.

GEN. SPIROSTREPHON.

S. lactarius. Scuta keeled. Segments 59.

S. cæsio annulatus. Scuta not keeled. Segments 32.

SUB ORD. SUGENTIA.

Parts about the mouth consolidated into a tubule fitted for the imbibition of liquid food.

FAM. POLYZONIDÆ.

Eyes simple, conspicuous.

GEN. OCTOGLENA.

Eyes eight.

O. bivirgata.

FAM. SIPHONOPHORIDÆ.

Eyes none.

GEN. BRACHYCYBE.

Rostrum much shorter than the antennæ.

B. Le Contii.

REMARKS ON THE NATURAL ARRANGEMENT OF THE MYRIAPODA.

SINCE this memoir has gone to press, the author has had the opportunity of examining some specimens of the Pentazonia of Brandt, and has been led thereby to extend and somewhat modify the classification of the Myriapoda as adopted in the body of the paper. It was stated that all modern authors, except Mr. Brandt, agree in dividing the Myriapoda into the two primary groups, Chilopoda and Chilognatha, calling them orders or suborders, according as they assign to the Myriapoda the rank of class or order in the zoological scale. Several reasons for following this were adduced, but in one particular I was led into error by a mistake of Mr. Newport. It was in the assertion that the Diplopoda* have *always* the genitalia in the anterior portion of the body, which is incorrect. Nevertheless, the appearance and structure of the two orders are so unlike that there can be no doubt of their distinctness. There is one difference which has never had the prominence given to it that, as it seems to me, it deserves. In the Chilopoda the head is always developed

* Chilognatha and Diplopoda are used here as synonymous, interchangeable terms—not with the meaning assigned to them in an earlier part of the memoir.

into *two separate segments*, the *posterior* of which gives origin to the immense foot-jaws, whilst in the Chilognatha the head is composed of but a single segment. An apparent contradiction of this exists, however, in the Cermatiidæ. When viewed from above, the head of one of this family appears to consist of but a single segment; but this is merely because the two cephalic scuta are fused together and consolidated into one, just as two body scuta are. The sternum of the posterior segment is entirely separate, and bears the foot-jaws as in the other families. In like manner, in the Lithobiidæ, the second cephalic scutum is very small, agreeing with the smaller scuta of the body.

The arrangement of the Chilopoda adopted in this memoir is very nearly that of Mr. Newport, which appears to be the true exposition of the plan of their creation. His families are natural, and are grouped according to their affinities. The Cermatiidæ deservedly stand at the top, on account of their more perfect organization and approach in some characters towards the Hexapoda. They have, as has been just stated, but a single scutum to two segments. In the Lithobiidæ the posterior scuta of each pair is atrophied, evincing a tendency to disappear, and, at the same time, the antennæ are almost multiarticulate. It is evident how these two facts ally them to the Cermatiidæ, and indicate a position at the top of the Holotarsia, which is confirmed by the fewness of the segments of the body and their active habits. On the other hand, the tendency of the first subsegments to become enlarged and approach the Diplopod type in the Geophilidæ, indicate their position as low in the scale, which is also confirmed by the great number of the segments of the body and the poorly developed nervous system.

Dr. Leach (Linn. Trans., xi), M. Gervais (Apteres, vol. iv), and Mr. J. E. Gray (Enycl. Anat. Phys., art. Myriap.), have placed the Chilopoda below the Chilognatha, a position which is totally repudiated by their more highly developed nervous and vascular systems, as well as by their habits and external form. They are the carnivora of the Myriapoda, and undoubtedly are superior to the vegetable feeders.

There have been offered, within a few years, three different classifications of the Chilognatha, by Messrs. Newport, J. E. Gray, and J. F. Brandt. Mr. Lucas has also published a synopsis (Hist. Nat. des Crustac. des Arachn. et des Myriap., tome iv, 1840), to which I have not had access, but, according to Mr. Newport, it differs from that of M. Gervais only in the names of the families.

J. E. Gray (*loc. cit.*) proposes to divide the Chilognatha into *six* families, the Iulidæ, Craspedesomidæ, Polydesmidæ, Glomeridæ, Zephronidæ, and Polyxenidæ. He does not attempt to arrange these into higher groups, and totally ignores the existence of the *Sugentia!* His *Craspedesomidæ* is probably the same family as that known in this paper as the *Lysiopetalidæ*, and the others appear to correspond with those of the same names, although his characters are very different.

M. Gervais (Apteres, vol. iv), divides the Chilognatha into *five* families,—the POLYXENIDÆ, GLOMERIDÆ, POLYDESMIIDÆ, IULIDÆ, and POLYZONIIDÆ. Of these, the *Polyxenidæ* and *Polydesmidæ* are the same as the same-named families of Gray, whilst the *Glomeridæ* comprise the *Glomeridæ* and *Zephroniidæ* of that author, and the *Iulidæ* his *Iulidæ* and *Craspedesomidæ*.

The *Polyzoniidæ* are the *Sugentia* of Brandt. Thus:

GRAY.	GERVAIS.
Polyxenidæ.	Polyxenidæ.
Glomeridæ. Zephroniidæ.	Glomeridæ.
Polydesmidæ.	Polydesmidæ.
Iulidæ. Craspedesomidæ.	Iulidæ.
None.	Polyzoniidæ.

M. Brandt (Recueil, p. 36), composes his "TRIBUS II" (Chilognatha) of all the Diplopoda, except the *Sugentia*. This tribe he divides into three families,—MONOZONIA, TRIZONIA, PENTAZONIA. The first of these comprises the *Polyxenidæ* and *Polydesmidæ* of Gray; the second, the *Iulidæ* and *Craspedesomidæ;* the third, the *Glomeridæ* and *Zephroniidæ* of that author. The *Sugentia* he divides into two sections, the OMMATOPHORA and TYPHLOGENA, which are respectively the *Polyzoniidæ* and *Siphonophoridæ* of Newport.

Mr. Newport (Linn. Trans., vol. xix), divides all the Chilognatha (including the Sugentia) into six families,—GLOMERIDÆ, POLYXENIDÆ, POLYDESMIDÆ, IULIDÆ, POLYZONIIDÆ, SIPHONOPHORIDÆ. Of these, the *Glomeridæ* includes the *Glomeridæ* and *Zephroniidæ* of Gray; the *Polydesmidæ* the *Polydesmidæ* and perhaps the *Craspedesomidæ** of the same author; the *Polyxenidæ* and *Iulidæ* correspond to his families of the same name, whilst the *Siphonophoridæ* and *Polyzoniidæ* are the *Sugentia* of Brandt. Mr. Newport then associates these six families in three groups, which he calls tribes: 1st. "PENTAZONIA, *Brandt*," comprising the *Glomeridæ*. 2d. "MONOZONIA, *Brandt*," comprising the *Polyxenidæ* and *Polydesmidæ*. 3. "BIZONIA, *Newport*," comprising the *Iulidæ*, *Polyzoniidæ*, and *Siphonophoridæ*.

* It is almost impossible to make out the exact limit of the Craspedesomidæ of Gray: it may be that Mr. Newport divides the group intended to be characterized by Mr. Gray, and puts only a part of it into his Polydesmidæ, and the rest into his Iulidæ.

Thus it will be seen that he elevates two of M. Brandt's families to the rank of tribes, and unites his Sugentia and Trizonia to constitute a third. To show, perhaps, a little more clearly and correctly the relations of these three arrangements, a table is appended, in which the positions of the families, &c., are altered from the places originally assigned to them by the authors, so as to compare with one another.

CHILOGNATHA.

Gray.	Gervais.	Brandt.	Newport.
Fam. Polyxenidæ.	Fam. Polyxenidæ.	Fam. Monozonia (*partim*).	Tribe, Monozonia (*partim*). Fam. Polyxenidæ.
Fam. Glomeridæ. Fam. Zephroniidæ.	Fam. Glomeridæ.	Fam. Pentazonia.	Tribe, Pentazonia. Fam. Glomeridæ.
Fam. Polydesmidæ.	Fam. Polydesmidæ.	Fam. Monozonia (*partim*).	Tribe, Monozonia. Fam. Polydesmidæ (*partim*).
Fam. Iulidæ. Fam. Craspedesomidæ.	Fam. Iulidæ.	Fam. Trizonia.	Tribe, Bizonia (*partim*). Fam. Iulidæ (*partim*).
None.	Fam. Polyzoniidæ.	Order, Sugentia. Sections, Ommatophora, Typhlogena.	Tribe, Bizonia (*partim*). Fam. Polyzoniidæ. Fam. Siphonophoridæ.

The characters employed by the several authorities in separating the various groups are so different and often so defective as to make it a task of some difficulty to understand the exact limits of their families, &c., and almost impossible to compare the several classifications so as to produce a regular synonymy of the genera. In some cases characters have been assigned as generic which vary not merely in the same species, but even in a single individual. Mr. Brandt has given more fully than any of the others the sum of the differences between his families; but even he has not seized and brought forward, as seems to me at least, the separating distinctive characters which run all through, so as to show the unity of the plan of the creation of this class; or, in other words, the successive steps in the Divine thought, which is embodied and, as it were, crystallized into form. Although this monograph of a single faunic group is not the place for a discussion of the history of the classification of the Myriapoda, yet it has seemed necessary to make this brief notice of and comparison between the works of the more recent authorities, before introducing what appears to the author to be the natural arrangement, which has been gradually developed by the various efforts; each adding something, each pushing forward a little towards the truth.

As has been stated before, the arrangement of the Chilopoda adopted is precisely that

of Mr. Newport, with an alteration of the characters. Had that able naturalist lived to make his studies of the second order as complete as those of the first, he doubtlessly would so have altered his classification of the Chilognatha as to have left just as little to be done in them.

In the first part of this memoir the Iulidæ were placed above the Polydesmidæ. I am convinced that this was an error, and that Mr. Newport is right in assigning them a lower rank. On glancing over the Chilopoda it will be seen that, as we descend the scale, the number of segments in the body constantly increases—or, in other words, the distinctive character which separates the Myriapods from the Hexapods and Crustacea, and allies them to the Annelids,—the multiplicity of segments, the absence of cephalization—is exaggerated. On applying this principle, it will be at once perceived that the Polydesmidæ must be placed above the Iulidæ, and the Glomeridæ, Leach (of Newport), be still higher, and thus be thrown next to the first order.

There is one character which allies the Glomeridæ to the Chilopoda, whose importance has been overlooked, and which seems to me to fix their place unquestionably. It is a curious circumstance that so careful a naturalist as Mr. Newport should misstate such an important anatomical fact. The genitalia in the Glomeridæ are placed, not as in the rest of the order, in the anterior portion of the body, but in the posterior, thus agreeing with the Chilopoda. It is very interesting to see a character which, in the higher group is characteristic of an order, thus becoming so degraded in a lower group as to belong only to suborders; and still more so when, as in this case, the same change takes place in the value of one or more other characters. On examining the mouths of the various families of the Chilopoda it will be seen that they are all formed after one common type; this indeed, is so altered that there is something more or less peculiar in each; but still there is one fundamental pattern to be traced all through, from the highest to the lowest. Not so in the Chilognatha; in them there are two distinct types. The one of these, which is the more aberrant from the Chilopod type, belongs to those families which are farthest from that order. The two characters just spoken of do not go side by side, as it were, but overlap one another; that is, the families nearest to the Chilopoda have the genitalia in the posterior portion of the body and the manducent form of mouth; whilst those which come next to these retain the latter, but have the genitalia removed forwards; then a step further and the families lose both these characters, having the sugescent mouth and the anterior position of the genitalia.

It seems to me, therefore, that we are thus brought to the three grand divisions—the suborders of the Chilognatha or Diplopoda; that these are the characters which, running through the class, furnish the groundwork for its arrangement. This is confirmed by a set of sub-characters, if, indeed, they ought not to be considered full characters. In these

again there is a similar but less marked degradation in value as we go from the higher to the lower order. There is very little alteration in the segments of the body in the Chilopoda. They are all formed after one common type; more or less parallelopipedal, with a solid sternum below and scutum above separated by membranous sides, which give origin to the appendages. The only important aberrations from this are the occasional fusion of two scuta into one, and at times a slight development of the atrophied subsegment. Not so in the Chilognatha; here there are three distinct types of form and composition of the segments. Now *each of these is peculiar to one of the three divisions indicated*, strongly corroborating their claims to rank as suborders.

There is one imperfection in my knowledge of the subject which I recognize and would guard against. I have never seen any of the species of the Polyxenidæ, and have not read a sufficiently accurate description of them and their anatomy to be able to assign their place; yet is it questionable but that they belong in one of the three suborders? There seems to be no room for a fourth division.

CLASS MYRIAPODA.

ORD. I. SYNGNATHA.*

Caput segmentis duobus distinctis compositum. Corporis segmenta subsegmenta unica efformata, singula pedum par unicum instructa. Organorum sexualium apertura ad extremitatem posteriorem.

ORD. SYNGNATHA, *Leach*, Linn. Trans., vol. xi, 1815, p. 381.†
ORD. CHILOPODA, *Latreille*, Cours D'Entomologie, 1831, p. 175, *et auctores*.

* Although it would seem much better to retain the name of Chilopoda, it having been so universally adopted, yet the prior appellation must have the preference. I have used Chilopoda all through this memoir through ignorance of the priority of Syngnatha.

† Mr. Newport states (Linn. Trans., vol. xix, p. 273) that the name Syngnatha was originally proposed by M. Latreille, and adopted by Dr. Leach. Dr. Leach, however, gives the name as his own (*loc. cit.*), and I have not been able to find it in any of the works of Latreille at my command. Mr. Newport does not refer to the place where the latter uses it.

Sub Ord. I. SCHIZOTARSIA.

Antennæ multiarticulatæ, corpore multo longiores. Scuta singula segmenta duo obtegentia. Oculi compositi. Tarsi multiarticulati, longissimi.

Fam. Schizotarsia, *Brandt*, Recueil, p. 26.
Tribe Schizotarsia, *Newport*, Linn. Trans., vol. xix, p. 274.

Fam. 1. CERMATIIDÆ. Scuta 8, singula stigmata mediana postice instructa.

Fam. Cermatides, *Leach*, Linn. Trans., vol. xi, 1815, p. 381.
Fam. Scutigeridæ, *Gray*, Cyclop. Anat. et Physiol., vol. iii, 1847, p. 546.
Fam. Scutigeridæ, *Gervais*, Apt., vol. iv, p. 56.
Fam. Cermatiidæ, *Newport*, Linn. Trans., vol. xix, p. 275.

Sub Ord. II. HOLOTARSIA.

Antennæ 12—60 articulatæ, corpore haud longiores. Scuta singula segmento unico obtegentia. Oculi simplices vel nulli. Tarsi 3 articulati, breves.

Fam. Holotarsia, *Brandt*, Recueil, p. 26.
Tribe Holotarsia, *Newport*, Linn. Trans., vol. xix, p. 275.

Fam. 2. LITHOBIIDÆ. Scuta 15, inæqualia, in seriebus duabus alternantibus disposita.

Fam. Lithobiidæ, *Newport*, Linn. Trans., vol. xix, p. 275, *et auctores*.

Fam. 3. SCOLOPENDRIDÆ. Scuta 21—23, in serie unica disposita. Pedum postremorum coxæ magnæ, incrassatæ, armatæ.

Fam. Scolopendridæ, *Leach*, Linn. Trans., vol. xi, p. 381 (*partim*).
Fam. Scolopendridæ, *Newport*, Linn. Trans., vol. xix, p. 275, *et Gervais*.
Fam. Scolopendridæ, *Gray*, Encycl. Anat. Physiol., vol. iii, p. 547 (*partim*).

Fam. 4. SCOLOPENDRELLIDÆ.* "Corpus pedesque breves, appendicibus styliformibus. Segmenta inæqualia; scutis 16 dorsalibus imbricatis. Antennæ elongatæ, articulis ultra 16."

* I have never seen a specimen of this family, and give the characters assigned by Mr. Newport.

Sub Fam. Scolopendrellinæ, *Newport*, Linn. Trans., vol. xix, p. 276.
Fam. Scolopendrellidæ, *Newport*, Linn. Trans., vol. xix, p. 374.
Fam. Geophilidæ, *Gervais*, Apteres, vol. iv, p. 56 (*partim*).

Fam. 5. GEOPHILIDÆ. Scuta numerosa, in serie unica disposita. Antennæ 14 articulatæ.

Fam. Geophilidæ, *Leach*, Linn. Trans., vol. xi, p. 384.
Sub Fam. Geophilinæ, *Newport*, Linn. Trans., vol. xix, p. 276.
Fam. Geophilidæ, *Newport*, Linn. Trans., vol. xix, p. 374.
Fam. Geophilidæ, *Gervais*, Apt., vol. iv, p. 56 (*partim*).
Fam. Scolopendridæ, *Gray*, Encycl. Anat. and Physiol., vol. iii, p. 547 (*partim*).

ORD. II. CHILOGNATHA.

Caput segmento unico compositum. Corporis segmenta subsegmentis duobus efformata, singula pedum paria duo instructa.

Ord. Chilognatha, *Latreille*, Cours D'Entomologie, 1831, p. 175.
"Ord. Diplopoda, *Blainville*," *Gervais*, Annal. Sc. Nat., 3me series, vol. ii, 1844, p. 59.*
Ord. Diplopoda, *auctores*, haud *Wood*.

Sub Ord. III. PENTAZONIA.

Os manducens. Organorum sexualium apertura ad corporis extremitatem posteriorem.

Fam. Pentazonia, *Brandt*, Recueil, p. 38.
Tribe Pentazonia, *Newport*, Linn. Trans., vol. xix, p. 276.

Fam. 6. GLOMERIDÆ. Oculi serie lineare utrinque dispositi. Antennæ in capitis fronte positæ.

Fam. Glomerides, *Leach*, Linn. Trans., vol. xi, p. 376.
Fam. Glomeridæ, *Newport* et *Gervais* (*partim*).
Fam. Glomeridæ, *Gray*, Encyclop. Anat. Physiol., vol. iii, p. 546.

* M. Gervais gives no reference to the place where M. Blainville indicated this order, and I have not been able to find it.

FAM. 7. SPHÆROTHERIDÆ.* Oculi aggregati. Antennæ in capitis latera positæ.

TRIBE SPHÆROTHERIA, *Brandt*, Recueil, p. 174, 1841.
FAM. ZEPHRONIIDÆ, *Gray*, Encyclop. Anat. and Physiol., vol. iii, p. 546, 1847.
FAM. GLOMERIDÆ, *Newport* et *Gervais* (*partim*).

SUB ORD. IV. STRONGYLIA.†

Os manducens. Organorum sexualium apertura in corpore antico.

SUB ORD. DIPLOPODA, *Wood*, haud *auctores*.‡

FAM. 8. POLYXENIDÆ.§

FAM. POLYXENIDÆ, *Newport*, Linn. Trans., vol. xix, *et auctores*.

FAM. 9. POLYDESMIDÆ. Scuta et sterna arcte conjuncta. Corporis segmentum annulum integrum faciens, laminis lateralibus instructum.

FAM. POLYDESMIDES, *Leach*, Linn. Trans., vol. xi, p. 381.
FAM. POLYDESMIDÆ, *Gervais*, Apteres, vol. iv, p. 123 (*partim*).
FAM. POLYDESMIDÆ, *Newport*, Linn. Trans., vol. xix, p. 277 (*partim*).
FAM. ONISCODESMIDÆ ET POLYDESMIDÆ, *Saussure*, Mem. Soc. Hist. Nat. Geneva, tome xv, p. 272.‖

FAM. 10. IULIDÆ. Scuta et sterna arcte conjuncta. Subsegmentorum posticorum sterna nonnihil obsoleta. Corporis segmenti annulus postice emarginatus, laminis lateralibus haud instructus.

* Mr. Brandt described the genus Sphærotheria a year before the figures of Zephronia were published in Griffith's Animal Kingdom (see Recueil, p. 173), and his name must stand for the genus. Moreover, the first indication of the family by Mr. Gray, which I can find, is that given above, which is several years later than that of Brandt.

† *στρογγυλος*, teres.

‡ To retain the name of Diplopoda with such an entire alteration of its significance, as I was at first disposed to do, would make a great deal of confusion, and there is really no principle of nomenclature or usage demanding that it should be done.

§ This family is inserted here, following Mr. Newport.

‖ It is very evident, as shown by M. Saussure, that Gervais was in error in placing the genus Oniscodesmus in the Glomeridæ. It does not seem to me, however, that the Oniscodesmidæ merit the rank of a family; the group appears to be nothing more than a sub-family at most.

Fam. Iulides, *Leach*, Linn. Trans., vol. xi, p. 377 (*partim*).
Fam. Iulidæ, *Newport* et *Gervais* (*partim*).
Fam. Iulidæ, *Gray*, Encyclop. Anat. et Phys., vol. iii, p. 545.

Fam. 11. LYSIOPETALIDÆ. Scuta et sterna disjuncta. Sterna obsoleta. Corporis segmenti annulus imperfectus.

Fam. Iulides, *Leach* (*partim*).
Fam. Craspedesomidæ, *Gray*, Ency. Anat. et Physiol., vol. iii, p. 546.*
Fam. Iulidæ, *Newport* et *Gervais* (*partim*).
Sub. Fam. Lysiopetalinæ, *Newport*, Linn. Trans., vol. xix, p. 278.
Sub Fam. 2. (Fam. Polydesmidæ), *Newport*, loc. cit , p. 277.†

Sub Ord. V. SUGENTIA.

Os sugens. Organorum sexualium apertura in corpore antico posita.
Ord. Sugentia, *Brandt*, Recueil, p. 45.

Fam. 12. POLYZONIIDÆ. "Ocelli conspicui, fronti inter antennas in seriebus transversis inserti."

Section Ommatophora, *Brandt*, Recueil, p. 49.
Fam. Polyzoniidæ, *Newport*, Linn. Trans., vol. xix, p. 278.

Fam. 13. SIPHONOPHORIDÆ. "Oculi nulli."

Section Typhlogena, *Brandt*, Recueil, p. 50.
Fam. Siphonophoridæ, *Newport*, Linn. Trans., vol. xix, p. 278.

* I am unable to decide how nearly the Craspedesomidæ of Gray coincide with this family.
† I have some doubt as to this synonym.

CORRIGENDA.

For *lamina* read *laminæ*, p. 191, et passim.
For *antenna* read *antennæ*, p. 148, et passim.
For *a hexapod larva and a myriapod*, p. 140, read *the hexapod larva and myriapoda*.
For *Iulus marginatus*, p. 190, read *Spirobolus marginatus*.
For *Craspedosomidæ*, p. 191, near the middle, read *Lysiopetalidæ*.

ARTICLE VIII.

ON THE HYDROLOGY OF THE BASIN OF THE RIVER SAINT LAWRENCE.

BY THOMAS EVANS BLACKWELL, M.I.C.E.

Read March 16, 1866.

INTRODUCTION.

THE subject of the following paper was suggested to the author, some four years since, while in company with the late lamented President, Sir William Cubitt, and the late Mr. J. K. Brunel, Vice-President of the Institution of Civil Engineers.

In accepting the proposal that he would prepare a paper originally intended for this Institution, respecting the Hydrology of part of British North America, the author had but a very limited view of the extent to which its ramifications would be likely to lead him. And at that time, too, there was very little prospect, from the nature of his occupations, of his being able to perform, to any adequate degree, a promise made with the intention of fulfilling it at an early period.

Still the subject was always an interesting one, and its study was aided to a certain extent by business which led him from time to time to make comparisons between the two great modes of inland communication, and this brought him in contact with individuals and afforded him knowledge of a number of circumstances which he felt would be interesting matter for a communication, even if they did not always represent subjects of a purely engineering character.

Materials for a large portion of the information which it has been his endeavor to digest to a presentable form, have been for the most part collected during a period of repose, that was necessary for the restoration of health, broken down for a time by unusual labor. In collecting and now reviewing these materials, the author has experienced the more relief, finding in it a return to former modes and subjects of thought. He is quite aware that much of the material, as well as the reflections thereon, may still have a crude and imperfect form; he trusts, however, to the leniency of critics, as he offers these remarks in good faith, and in the belief that the subject will be interesting especially at this period, seeing that a large portion of the inland waters of that part of North America now under consideration is to be viewed as common to both the British and American nations.

The traffic during the year 1861, has been affected by a number of circumstances, the chief of which are to be found in the unhappy differences which have paralyzed or blockaded all trading operations south of Pennsylvania; and these have had the effect of diverting into fewer channels the produce of a most abundant harvest, while favorable prices have likewise prevailed in the European markets, causing a great increase to the trade of the St. Lawrence.

TOPOGRAPHY.

The hydrographical basin of the St. Lawrence is divisible by geographical lines and geographical features into six basins. *The first* embraces the Gulf and the lower river as high as Three Rivers, and includes the tidal estuary of the Saguenay as high as Chicontimi, seventy miles above its mouth.

The second is the basin of the St. Lawrence proper, embracing the river between Three Rivers and the Thousand Islands, a distance of two hundred miles; together with the Ottawa River, between Montreal and the Lac des Chats, a distance of one hundred and twenty miles; the St. Maurice, from its mouth to the entrance of the mountains, thirty miles; and on the other, or southern side, the valley of the Chaudiere, and the St. Francis, the plain of the Richelieu, and the valley of Lake Champlain and Lake George. From the head of Lake George to the mouth of the Richelieu, is one hundred and ninety miles.

The third basin embraces Lake Ontario, with its southern tributary, the Genesee River, descending from the table lands of Pennsylvania, through Western New York, and its northern tributary, the Trent and Otonabee, meandering through a labyrinth of lakes which dot the uneven table land between the shore and the foot of the Northern mountains; the principal, taken in a west-east order, being Scugog, Balsam, Camerons, Sturgeon, Pigeon, Buckhorn, Mud, Salmon, Trout, Rice, Stoney, White, Belmont, and Marmora Lakes.

The fourth basin is that of three upper great lakes, embracing Lakes Erie and St. Clair, Lake Huron and its Georgian Bay, with Lakes Simcoe, Nepessing, and Tamagamingue, Lake Michigan and its Green Bay, together with a narrow fringe of short affluents, draining small areas in Northwestern Ohio, Northern Indiana, and Eastern Wisconsin, as well as the two principal peninsulas of Michigan and Upper Canada.

The fifth is the basin of Lake Superior, separated from the other great lakes by the Sault Ste. Marie, and fed by the smaller lakes and rivers from the unexplored lands beyond.

The sixth is the great general basin of the North; a country of unknown extent, studded with lakes, and traversed by the mighty branches of the Ottawa, by the St. Maurice, and by the rivers flowing from all sides into the Lake St. John, and Saguenay.

The first, or tidal basin, of the Gulf and Lower St. Lawrence, is in fact a prolongation

of the basin of the St. Lawrence proper, eastward, beyond Three Rivers, and differs from it no otherwise than in being tidal, and therefore, also, of greater breadth. As it is of no particular interest in the discussion of the hydrography of the flowing waters of Canada, and as its limits are also prolongations of the limiting mountain ranges of the basin of the St. Lawrence River proper, no further notice of it seems necessary, than to mention that the influence of the tide is felt upon the surface of Lake St. Peter, a broad expanse of the river, beyond the stated head of tide at Three Rivers. The St. Maurice River enters the St. Lawrence not far below this lake, its embouchure being nearly on the boundary between the two first basins. This point is ninety miles above Quebec, where the lower river, as it is called, commences. The Saguenay comes into it one hundred and ten miles below Quebec; and one hundred and twenty miles still further down, at Point des Monts, the estuary, widening suddenly on the north, may be considered as merging in the Gulf, but the south shore moves forward in an unbroken curve for one hundred and thirty miles more to Cape Gaspé. The whole length of the tidal basin may be therefore called four hundred and fifty miles. The basin of the St. Lawrence proper is limited, both on the northwest and on the southeast, by mountain ranges. That on the north is called the range of the Laurentide Mountains. That on the south is called by various local names, but may be termed the range of the Green Mountains. The Laurentide Mountains begin in Labrador, at the Straits of Bellisle, and run on in a southwest direction parallel in several instances, spreading out southwards so as to form bold bluffs and mountains close to the water's edge, as at Cape Tourment, which is sixteen hundred feet high; they range at an average distance back from the Gulf and river from twelve to fifty miles; across the Saguenay and behind Quebec, across the St. Maurice and behind Montreal, up the Ottawa to the Lac des Chats, a distance of at least seven hundred miles. They form the northern background to all the pictures of the river scenery. They are composed of the oldest rocks known to geological science, and spread themselves at an average elevation of about two thousand feet above the sea, back from the front line just described, over a table land of forests and lakes, far towards the waters flowing into Hudson's Bay; westward, beyond Lakes Huron and Superior; and southward, across the Ottawa to the foot of Lake Ontario, and across the St. Lawrence at its outlet from the lake, into Northern New York, filling up the country west of Lake Champlain with mountains, some of which exceed five thousand feet in height above the sea. The western or head line limit of the St. Lawrence River basin is at the foot of the Laurentian rocks, from Lac des Chats on the Ottawa, to the Thousand Islands on the St. Lawrence. Its northern border is formed by the Laurentide Mountains north of the Ottawa, and its southern by the Laurentian Adirondack Mountains of New York, along the Canada Boundary Line. The triangular space between the Ottawa and the St. Lawrence, with its apex at Montreal, is a great

plain of almost horizontal lower Silurian rocks, covered with variable depths of post-tertiary clays, showing themselves in remarkable terraces around the border lines, at an average elevation of two hundred feet above the plain. Five or six masses of trap form as many isolated mountains, from six hundred to twelve hundred feet high, standing upon the plain like stranded ships upon a beach. One of these is the mountain of Mont Royale. Around these island-mountains the terraces of post-tertiary clay are visible. The plain, however, is not confined to the triangular space between the two great rivers; it spreads on eastward, past the Richelieu and Lake Champlain, to the foot of the Green Mountains, next to be described, and so along the range past the Yamaska and St. Francis, in a long and narrow belt, even to Quebec. The whole area of this plain thus described contains about eighteen hundred square miles, the most of which is fertile arable land, well watered and level, through the midst of which flow the two great rivers named.*

The only important adjunct of the basin of the St. Lawrence proper is to be found in the extension of this lower Silurian plain southward up the Vermont, or eastern shore of Lake Champlain, the western, or New York shore of which rises at once into the Adirondack heights. Starting from the head of Lake Champlain, a narrow winding gorge between high mountains of Laurentian rocks terminates in Lake George (so famous among tourists), the upper end of which is separated only by seven miles from one of the principal head rivers of the Hudson, the difference of elevation, however, in favor of Schroen River being at least five hundred feet.

We must now describe the eastern portion of the southern barrier of the St. Lawrence basin. It has no connection whatever with the western portion already described. Lake Champlain, with its side plain of lower Silurian rocks, opening up a great highway between Canada and the Atlantic States, isolates the Adirondack Mountains on its western shore from the Green Mountain range, from which its eastern affluents descend. Unlike the Laurentide Mountains on the north, the southern limit of the basin is a corrugated plateau or chain of parallel ridges of quartzite, slate, and limestone rocks, of lower Silurian age, about fifteen hundred feet high, upon the top of which rise to a still loftier elevation the Schick-Shock, and other isolated groups of synclinal lower Silurian mountains, probably connected geologically with the Katahdin Mountains of Maine, and the White Mountains of New Hampshire. Commencing at Cape Gaspé, this barrier ranges along the southern shore of the Gulf and Estuary, in a graceful curve, three hundred miles, to the neighborhood of Quebec, where it leaves the river, by slowly diminishing the radius of its curve, towards the south. Crossing the Chaudiere and St. Francis, the waters of which

* A view of this plain, looking southeast, bounded by the mountains just described, from the mountain of Montreal, accompanied the memoir.—Pub. Com.

drain back valleys, it skirts the great plain, and enters the State of Vermont, which it traverses under the name of the Green Mountains, three thousand feet high. It is continued as the Berkshire Hills in Western Massachusetts, and as the Taconic Hills in Eastern New York; crosses the Hudson as the Highlands of West Point, and the Delaware as the Durham, or Easton Hills. Lost for a few miles between the Schuylkill and the Susquehanna at Harrisburg, it re-emerges from beneath the New Red plain as the chain of the South Mountains of Southern Pennsylvania. In Maryland, it crosses the Potomac at Harper's Ferry, to form the Blue Ridge of Virginia, and the Smoky Mountains which divide Tennessee from North Carolina; where the Black Mountain group, a little east of the line, attains elevations ranging between six and seven thousand feet above the sea. Traversing Georgia, the chain sinks beneath the Cretaceous plain of Middle Alabama, and is seen no more, after having a geographical range of not less than sixteen hundred miles.

The geological cause for the shape and position of the estuary and lower river of the St. Lawrence must not be overlooked. It is to be found in the presence of a remarkable fault or fissure in the crust of the earth, running close along the southern shore from Gaspé to Quebec, thence through the middle of the plain up the east shore of Lake Champlain, and down the Hudson River into New Jersey. All the rock formations on the northern and western side of this fault, both in Canada and in New York, are thrown down to a depth varying from five to ten thousand feet. The top of the lower Silurian system in the west wall of the fault, is brought down to a level with the bottom of the same system in the east wall. In these soft Hudson River slates, as they are called, have therefore been excavated, all along on the west side of the fault, the estuary of the St. Lawrence, the Lakes St. Peter and Champlain, and the Hudson River valley; for the same agency brings abruptly to an end in the Catskill Mountain, three thousand feet high, on the west bank of the Hudson River, the Alleghany Mountain system coming up from the southwest through Middle and Northern Pennsylvania.

Passing now to a description of the basin of Lake Ontario, its limits are of quite another order. Its eastern end abuts against the Laurentian rocks of the Adirondack Mountains of New York, and its outlet is over the low and narrow barrier of the same forming the Thousand Islands. The lake itself is excavated out of the soft lower Silurian rocks described. The northern limit of the basin is an east and west line, about fifty miles back from the northern shore; the western continuation of the Laurentide Mountains in their course from the Thousand Islands to the foot of Lake Simcoe. Its southern limit is made by three remarkable escarpments, ranging in parallel east and west lines from the Hudson River to Lake Erie, caused by the broad outspread and almost imperceptible southern dip of the whole Palæozoic system, from the Potsdam sandstone at the bottom of the Silurian, to the coal beds at the bottom of the Carboniferous rocks. This dip being towards the

south, and away from the great lakes, the basset edges of the formations necessarily front the north, and form a series of steps or terraces facing the north, while down the southern slope of these strata flow all northern subsidiaries of the Delaware, Susquehanna, and Ohio Rivers, almost from the margins of the lakes themselves.

The lowest escarpment is that of the Niagara, or Middle Silurian Formation, which commences at a slight elevation between Albany and Utica, along the south side of the Mohawk Valley, and crosses the Niagara River at Lewiston. Back of this runs the escarpment of the Helderberg, or Lower Devonian limestones, forming high hills south of the Mohawk, but dying away as it approaches Lake Erie. Still further south, and at a still higher elevation, runs the high escarpment of the upper Devonian sandstone, from the base of Catskill Mountain, on the Hudson, to Lake Erie, along the southern shore of which it ranges away beyond Cleveland into Southwestern Ohio. On the summit of this uppermost platform, and at an elevation of fifteen hundred feet above the sea, and one thousand feet above Lake Erie, lie outspread the broad, flat, shallow basins of the bituminous coal field of Pennsylvania and Ohio, constituting the great Appalachian coal basin. From the northern part of this coal field the Genesee River cuts down through all the escarpments into Lake Ontario.

Across the soft Lower Devonian terrace, between the middle and upper escarpments, lie in parallel north and south cut valleys, the deep and narrow Lakes Canandaigua, Cayuga, Seneca, Crooked Lake, Auburn, and Skaneateles, all of them, with Lake Oneida at the foot of the lowest escarpment, drained by the Oswego River into Lake Ontario. But the principal drainage of Southern New York, even from the edge of the Niagara escarpment, is the other way southward, through the upper escarpment, and by deep gorges in the Alleghany Mountains of Pennsylvania, by the Susquehanna River, and Chesapeake Bay, into the Atlantic. In Western New York, the same set of the waters away from Lake Erie carries the drainage into the Alleghany, the Beaver, and other affluents of the Ohio, the head waters of which, therefore, overlook Lake Erie, a thousand feet, from a distance of scarce a dozen miles. There is one spot in Potter County, Pennsylvania, where the same cloud will shed its waters by the Genesee into the Gulf of St. Lawrence, by the Susquehanna into the Chesapeake Bay, and by the Alleghany into the Gulf of Mexico. Following the lowest or middle Silurian escarpment across the Niagara River, we see it become the constant limit of the basin of Lake Ontario.

At Lewiston Heights it is three hundred and sixty feet above the lake. Rising slowly as it enters Upper Canada, it sweeps close around the head of the lake, runs northward, and then northwest along the southwest shore of Georgian Bay, and projects into Lake Huron at Cape Hurd; casting off southwestward all the way the waters of the peninsula into Lakes Erie, St. Clair, and Huron, and forming a well-defined barrier for a separate

water-basin between three hundred and four hundred feet above that of Lake Ontario. On the top or back of the escarpment, south of Georgian Bay, are piled upper Silurian strata to an elevation of fifteen hundred feet above the sea, in what are called the Blue Mountains. By the run of the escarpment, Georgian Bay would seem to be excluded from the region of the upper lakes, and to belong properly to the area of Lake Ontario. It and Lake Simcoe, in fact, lie in an excavation of the same lower Silurian rocks with the Gulf of St. Lawrence, Lake Champlain, and Lake Ontario, and in the prolongation of the belt of small lakes to the north of Lake Ontario. A water communication by these larger lakes and the streams which connect them, has been, in fact, accomplished by means of a system of canals, which has replaced the old portages or carrying places where no navigable water passages existed. Yet in spite of this geological and commercial connection, Georgian Bay is an arm of Lake Huron, and at a level above Lake Ontario of three hundred and forty-four feet, while Lake Simcoe, which communicates with it, lies one hundred and thirty-three feet higher. The explanation of this anomaly is to be found in the rise of the surface of the lower Silurian rocks in that direction, the whole broad outcrop being covered over with a sloping plain of northern drift, among the hillocks and ridges of which lie the smaller lakes, and a barrier of which effectually cuts off all hydrographic connection between Lake Ontario and Georgian Bay. Excavated, as has been said, in the same soft rocks of the lower Silurian system, in which Lake Champlain and the Gulf of St. Lawrence have been excavated, Lake Ontario would form part of the same water-basin with them, were it not for the intervention of the Laurentian rock barrier at the Thousand Islands. There was a time, no one doubts, and that in recent geological days (when this part of the continent was submerged from three hundred to four hundred feet beneath the present ocean level), that two broad estuary connections were established between it and the ocean: the one round the Adirondack Mountains to the north, over the plains of Montreal, the other to the south, through the valley of the Mohawk. At that time, of course, Northern New York was one island, and Vermont and Western Massachusetts was another; while the north shore of the Gulf of St. Lawrence extended up along the foot of the Laurentide Mountains to the Lac des Chats.

The basin of the Devonian lakes, as they are called, is now to be described. The Niagara barrier seems to end at Cape Hurd, the north of Georgian Bay, but is, in fact, continued as the Manitoulin Islands around the head of Lake Huron, and the foot of Lake Michigan, through the Straits of Mackinaw, and forms those two remarkable promontory peninsulas which almost isolate Green Bay from Lake Michigan, in the same way as the escarpment isolates the Georgian Bay from Lake Huron. Geologically considered, Green Bay is yet another of the lower Silurian lakes; while hydrographically, it is but an arm of Lake Michigan. The Niagara barrier, much attenuated, and therefore low, continues south-

ward to the head of Lake Michigan, obliging the waters of Wisconsin to feed Green Bay before they can enter Lake Michigan.

Curving round the head of Lake Michigan, the Niagara rocks sweep eastward in a narrow belt to the head of Lake Erie, thus closing a hydrographic, as well as a geological circle, around the great peninsula of Michigan, with its isolated coal basin in its centre. In troughs hollowed out of the concentric belt of soft Devonian shales, just inside this circle of Niagara rocks, lie Lakes Michigan and Huron; and in a third trough excavated from the same shales, thrown eastward by the great Detroit and Cincinnati anticlinal, lies Lake Erie, also. This anticlinal is a swell of the earth's crust, separating the Appalachian coal area of Eastern Kentucky and Tennessee from the coal area of Western Kentucky and Illinois, and casting off the rock-dips gently east and west from its broad back. Commencing in Tennessee, it crosses the Ohio in the region of Cincinnati, and the head of Lake Erie into Upper Canada. But for this anticlinal Lake Erie would have had no existence; and the other two lakes must then have emptied their waters by way of Georgian Bay into Lake Ontario.

The escarpment, limiting Lake Erie on the south, has already been described, and the disposition of the head waters of the Ohio to form along its summit and flow south. In like manner, but in a more remarkable degree, the belt of Niagara rocks, circling around the head of Lake Michigan, cuts off the drainage into it. The head waters of the Illinois, a tributary of the Mississippi, and of the Wabash, a tributary of the Ohio, start close to its margin on their long career to the Gulf of Mexico. In fact, there is a marsh but five miles back of Chicago, only seventeen feet above the level of the lake, and in wet seasons its waters flow partly into the lake and partly down the Illinois, as will be described more particularly in another place. Only at the head of Lake Erie can drainage be said to enter, in any abundance, the Canadian Basin. Here the Miami brings in the waters of a belt of Lower Devonian country of no great size, lying along the anticlinal in Northern Indiana.

The basin of Lake Superior lies apart from the other great lakes, at the extreme northwest limits of the formations which have been described. Its immense area, and profound trough, nearly eight hundred feet deep, excite new interest by their surroundings. Hollowed out in part from the lowest Silurian rocks, it is the highest of the lakes. Its mineral resources, copper and iron, belong to still older formations, which surround it on all sides except the south. Laurentian and Huronian mountains support a back country of forests and lakes of great extent, which pour their waters into all its shores, and offer commerce with the unknown regions of the interior of the continent: in fact, the western end of the great northern basin drained by the Ottawa, St. Maurice, and Saguenay.

All that can be said of this northern basin is, that it is a wilderness of small lakes, the

areas of which, if summed together, would make a water surface nearly, if not quite, as extensive as Lake Ontario, and of rivers rivalling in magnitude the largest affluents of the St. Lawrence.

The Ottawa, by which the waters of this region find their way out of the Laurentian mountains, at the Lac des Chats, upon the plain of Montreal, is so copious of flood, that it colors with its brown waters the north side of the current of the St. Lawrence River as far down as Lake St. Peter; just as the turbid waters of the Missouri color the west side of the Mississippi far below St. Louis. Large as the St. Maurice River is, it is not larger than the Gatineau, one of the northern branches of the Ottawa. The Saguenay is but a tidal estuary arm of the Gulf of St. Lawrence, the outlet of Lake St. John; but into this also flows from all sides the drainage of another section of the same area. Reviewing, then, the narrow southern and western border, and feeble tributaries of the chain of great lakes, and the small rain areas of the peninsulas of Michigan and Upper Canada inclosed between them; and on the other hand, the great outspread of the northern basin, its many large rivers and standing lakes, it may be justly said that the basin of the St. Lawrence is the basin of Canada; that it belongs almost wholly to the North, and finds its grandest hydrographic traits of character in a country almost unexplored. Its whole area Sir William Logan has stated at five hundred and thirty thousand square miles, more than eight-tenths of which he says belongs to Canada, and the residue to the United States. Its chief peculiarity lies in the reservoirs of water, great and small, scattered over almost its entire surface, protecting its rivers from those disastrous floods which desolate the river banks of other regions of the world, especially the neighboring valleys of the Western States. So effectual is this protection, that the total variation of the level of the St. Lawrence River, due to excessive rains or melting snows, and exclusive of the local influence of the ice-gorges at its narrows, does not exceed three to four feet; whereas the Ohio River at Cincinnati has been known to rise sixty feet in as many hours.

Having now described the leading features of the topography of the basin, and shown how this must depend so largely upon the geological features of the whole district, it will be interesting to refer to a table which has been prepared in considerable detail, and submitted, in the Appendix, marked 5, giving a list of the various lakes. It will be seen that sheets of water, besides the larger lakes, the names of which have frequently occurred in this description, are very numerous, and that they are found extending over a vast area of country principally on the north side of the longitudinal axis of the basin.

It may be said that all the largest of these lakes are hollowed out in the old Laurentian formation, and in its bands of limestone; and, as has been mentioned, similar depressions occur in the azoic rock of the Adirondack country. The smaller lakes occur, also, to a very large extent, in drift on both sides of the axis of the valley; and of these we may

mention the series lying upon the course of the Otonabee and the Trent, on the north side of Lake Ontario. But the most extensive development of these small surfaces of water occurs in that flat region of country forming the great southern peninsula of Michigan, which is generally described as covered with a great thickness of drift.

In the course of the Michigan survey, the topographers have already laid down on the maps fourteen hundred and twenty-five lakes, occupying areas of from one thousand to three thousand five hundred acres, which would be in the proportion of one acre of water to thirty-nine acres of land.

We cannot properly pass from this subject without referring to Lake St. Clair, which is only a shallow depression in the drift. It consists of an expansion of the straits leading down from Lake Huron to Erie, and may be assumed as twenty-one miles in length, by eighteen and a half in width. Its depth, as will be seen by the section, is only twenty feet, and like Lake Erie, which does not exceed eighty-four feet, is the recipient of the alluvial deposits of the rivers which flow into it. The inlet to Lake St. Clair is an interesting delta, and islands of alluvium are constantly forming, which tend to choke up its numerous channels. Although the average depth of Lake St. Clair is about twenty feet, the navigation through it has to pass a channel which is naturally about ten feet; and the dredging out of this channel to the depth of thirteen feet, by the United States Government, is referred to in another part of this paper.

A moderate gale of wind soon raises a sea in this shallow lake, causes the whole to become turbid, and tends thus to distribute the detrital matter, and to convey it through the Detroit straits into Lake Erie, where similar accumulations, on a larger scale, occur. The depth of Erie over its upper end scarcely averages eighty feet, its deepest part being near the east end, where it begins to narrow towards the outlet, in the direction of Niagara. Here, too, an ordinary storm raises a very heavy and somewhat dangerous sea, and soon disturbs the bottom, and favors the distribution of natural deposits which settle in calmer weather in the *upper* portion of this shallow basin.

Reflecting upon the relative levels of these upper lakes, as given in the table before referred to, and the peculiar character of the water-shed which limits the basin on the west side of Lake Michigan, it will be seen that if the barrier now regulating the discharge through the Niagara River were lifted to the extent of about thirty feet, the whole of the great lakes would be converted into one vast sea, on a uniform level, which, while placing under water from eight to nine thousand square miles in Western Canada and Michigan, and the other borders of the lakes, would determine the direction of the outlet of this great basin towards the Mississippi, and place the present dividing ridge from seven to eight feet below the surface of this expanded sheet of water.

RIVER ST. LAWRENCE.

The whole of the River St. Lawrence, from its entrance at Pointe des Monts to Montreal, has been elaborately surveyed by Admiral Bayfield; and the charts and sailing directions which are published by the Admiralty are so extensive and so well known, that it is deemed wholly unnecessary to make any statements with respect to the navigation of the tidal part of the river.

The tides at Quebec range, upon the gauge which is there fixed, from eighteen feet at spring tides, to thirteen feet at neaps. Unusually high spring tides, accompanied with gales of wind from the northeast, occasionally give from two to two and a half feet more at high water, and a smaller range towards low water, but the mean for all practical purposes, may be taken at seventeen feet. At neaps the tides range about eleven and a half feet, the low-water level both at spring and neaps rarely varying more than eighteen inches. Spring tides are felt up the river as far as the entrance into Lake St. Peter, which for all hydrographical purposes may be described as the head of tidal navigation. From this point onwards the river has for some years past been the object of constant superintendence; and works of considerable magnitude have been carried out for improving this navigation, together with that of the river up to the harbor of Montreal.

The depth of water existing on the Flats of St. Peter in 1845, is reported by the authorities as only capable of passing vessels drawing not more than eleven feet at low stages of the river, and other impediments existed in the river above. But under the direction of the Harbor Commissioners of Montreal, a general deepening of the whole of the fairway of the navigation, wherever necessary, is being carried out. The works consist of a channel dredged out in the clay and mud bottom of Lake St. Peter, three hundred feet wide, and is intended to afford a depth of water, when completed, of twenty-one feet at low water.

According to the statements made to the Harbor Commissioners by the Engineer, to the end of 1860, the work has been proceeding with great vigor. There are five dredges employed, with hopper barges and scows; and the work performed during the year 1860, stated to have been two hundred and seven thousand seven hundred and thirty-two cubic yards, at a cost of $57,527, or $0.27½ per cubic yard excavated, including superintendence, but exclusive of the interest on the cost of machinery and boats. From this point to Montreal, the general course of the river is direct, although the fairway of the channel is somewhat tortuous, and there are many islands of alluvium which divert the direction of the fairway, but all the courses are duly marked and lighted, and during last year no difficulty was felt in clearing vessels through the improved channel between Montreal and Quebec, drawing nineteen feet of water, the Flats of Lake St. Peter having then about

twelve feet of water on them. The slope on the surface of the river, from the head of Lake St. Peter to the foot of St. Mary's current (which is a small rapid at the lower end of the harbor of Montreal), is about two and three-quarter inches per mile, and the average velocity is one and a quarter miles per hour in the fairway channel. The rapid last mentioned is formed in a contracted part of the river, between St. Helen's Island and the north shore, which is here about two thousand feet across. The current through the rapid, in ordinary stages of the water, is about four and three-quarter miles per hour, but occasionally reaches from five to five and a quarter miles per hour.

The harbor of Montreal is shown by the annexed plan, and has wharves for accommodation of the traffic which it has for the last few years obtained, and which exceeds two hundred and fifty thousand tons per annum. This accommodation has been obtained by building wharves of cribwork out into the stream of the St. Lawrence, and by dredging out a suitable depth for vessels to lie alongside. This harbor was, until the construction of the canals, the head of navigation for sea-going craft; and until the commencement of the canal system, the real difficulties of the navigation of the river began at this point.

It was a great thing to witness a river, rarely less than two miles in width, gradually extending to twenty miles, flowing for five hundred miles of its course with great regularity for eight months in the year, and affording accommodations for square-rigged ships of six hundred tons, which then reached Montreal; it was another thing to attempt the movement of freight from this point upwards. The work up the Valley for the first ten miles above Montreal, was performed either by the Portage Road, so called, or by dragging up by the sides of the rapid current, with long teams of oxen or horses, sometimes in, sometimes out, of the water; and such portages as these occurred at nine distinct points between Montreal and Kingston, and similar portages were also necessary on the Ottawa.

The work was chiefly done by canoes or large bateaux, which rarely exceeded twenty-five tons burden; and it may readily be understood how the freights and charge, for the movement of goods and passengers, acted as a most formidable barrier to progress in the settlement of the country; and as movements over the deep alluvial soil of the valley, in a state of nature, could only be undertaken either in the driest season of the year, or in sleighs over the snow, it is not surprising that forty years ago, the settlements of Canada consisted only of a few villages and farms fringing the most favorable sites on the banks of the river and Lake Ontario. Still more difficult of access was the country, and more sparse the population of those then remote regions on the border of the upper lakes.

The Niagara Portage was, however, established early in the present century, and assumed a great importance up to the time of the completion of the Welland Canal. While up the Ottawa, the country at the beginning of the present century, on both sides of the river,

could have advanced but little in material prosperity and settlement since the time when the Jesuits narrated (in their most interesting letters written one hundred and fifty years before), their occasional visits to these regions.

There are, however, two periods which we must now mark, as the first great steps towards the real progress of the country; and one of these which has only fulfilled in American waters what has been the result in all others, is that of the commencement of steam navigation; the other is the establishment of the canal system.

It is an agreeable fact to state that on the River St. Lawrence, and on Lake Champlain, almost the first successful attempt was made to employ steam for the propulsion of vessels; and the following narrative, drawn up by a local committee, will be read with some interest by engineers:

"In 1807, Fulton first launched his first steamer on the Hudson. In 1809, his example was followed on Lake Champlain and the St. Lawrence.

"The first movement towards the steam navigation of the St. Lawrence was made by the late Hon. John Molson, in conjunction with David Bruce, a shipbuilder, and John Jackson, an engineer.

"The vessel built by them was the 'Accommodation;' she was but a small boat, seventy-two feet in length, with sixteen feet beam, propelled by an engine constructed by Mr. Jackson, of not much exceeding six horse power.

"It required no ordinary courage and enterprise on the part of these pioneers, to undertake the difficult task which they thus essayed. But all the difficulties encountered were successfully overcome, and on All Saint's Eve, 1809, the steamer started on her first voyage to Quebec. As she passed after nightfall some of the settlements, going without sails against an easterly wind, the sparks flying out in a continuous stream from her funnels, as has been the case elsewhere, the consternation of the inhabitants residing along the banks of the river, at the unwonted sight, must have been very great; and we can easily suppose that it might well be taken for some phantom ship, or other fearful apparition. It was held dangerous to continue their progress through the night, and three days were consumed in the downward trip of one hundred and eighty miles to, and four days in the upward one from, Quebec. Therefore it was, that those who had to reach Quebec either by the tedious land route or the more uncertain transport of sailing craft upon the river, hailed the prospect of this more swift and certain steam navigation with satisfaction. The experiment proved a failure. The engine was, of course, too weak, and of imperfect construction.

"Yet notwithstanding the lack of immediate success, and the money lost by the first attempt, Mr. Molson did not abandon the enterprise. His practical mind saw, even in that failure, the certainty of a final success, which he lived to realize. He went to England,

and there contracted with the firm of Bolton & Watt, for the engine of a larger boat, some of the castings and rougher part of which were made in Lower Canada. The London engine builders could build the engine, but they knew nothing of the appliances by which it was adapted to navigation: these required to be furnished here.

"In 1811, the new vessel, the 'Swiftsure,' was launched and at work, and in 1812, did 'the state some service' in the transport of troops and stores during the unhappy interruption of our relations with the United States. This boat had nearly five times the power of the 'Accommodation.' Her length was one hundred and twenty feet, her beam twenty-four feet, the engine was rated at twenty-eight horse power, and she was fitted up and equipped in all respects in a superior manner.

"The 'Malsham' was the next boat placed on the line, still superior to the 'Swiftsure;' and after her the 'Lady Sherbrooke,' vessels at that time of very considerable tonnage and power.

"At this period the river was not lighted and buoyed as at present: it was, therefore, thought unsafe to run after dark. The pilots, too, were less experienced than at present: it was, therefore, usual to anchor at night. Frequent and expensive delays were also caused by strong southerly winds in getting up the current St. Mary, more especially when the boats were heavily loaded, as they generally were at that time. Oxen and horses were sometimes employed to tow the vessels up this very powerful current.

"In a few years later than the period referred to, we find the St. Lawrence Steamboat Company, and their competitors (afterwards their coadjutors) the Montreal Towboat Company, running their boats during the night with perfect safety, and ascending the current in any state of the wind, triumphing over all the former difficulties of the navigation.

"To the late founder of the St. Lawrence Company, the Hon. John Molson, the celebrity of being the first to establish steam traffic on our noble river must be accorded,—a traffic which, by the enterprise of Upper Canada and that of our neighbors in the adjoining States, is now made to enter from Superior City, on Lake Superior, and Chicago, on Lake Michigan, to the ocean,—aye, and across the ocean, also.

"To the late Robert Hamilton, Esq., Upper Canada is indebted for the first steamer on Lake Ontario, the engine of whose boat was constructed from the model of the 'Malsham's' engine.

"In contrast with the dimensions, power, and speed, of the little 'Accommodation,' we subjoin those of the 'John Munn,' the largest steamer now (1856) plying between this city and Quebec:

Length,	312 feet.
Breadth of beam,	29 "
Cylinder,	72 inches.
Stroke,	11 feet.

." She makes the downward trip easily enough in ten hours, and the upward in from eleven to twelve hours."

In 1819, the canal system was begun in the construction of the Lachine Canal, and following this, other works of the same nature, for the improvement of the Ottawa and the St. Lawrence, which will hereafter be described.

From Montreal, up the natural course of the river, there is a series of rapids which give a high velocity to the water, in some cases not less than eighteen miles per hour, which give rise to a rapid turbulent stream, over a rocky bottom of an uncertain depth; alternated with lakes or wider stretches of the river, which have reduced the velocity to a minimum of half a mile per hour, in the centre of Lakes St. Louis and St. Francis.

The portion of these rapids and lakes, as well as the width and depth of the river, can be best described by referring to a map, which is appended to this statement, giving all the leading features for the practical consideration of this subject. And attention is particularly invited to the large general charts of the river from Brockville to the neighborhood of Montreal, which afford the best available material for the study of this interesting river. A tabulated statement is also given in the Appendix (marked 7) to this, which gives the slopes of the surfaces; but it may be remarked generally, that while the maximum slope in the Sault Rapid is on an average seventeen feet per mile, the minimum slope of the flat part of the river, between Brockville and Prescott, where flowing in a tolerably uniform *regime*, is one inch per mile for a length of about twelve miles.

It is to be regretted that circumstances have not encouraged or induced the undertaking of any sufficiently extensive observations upon the discharge of this river, through these or any other localities; for unless undertaken professionally, it is scarcely to be expected that a zealous devotion to science *per se*, would venture upon a set of experiments which, to insure sufficient accuracy, must be continued over a long period, and especially under circumstances such as those which have been referred to in another part of this paper.

ST. CLAIR FLATS.

Among the works undertaken on the line of inland navigation, is the deepening of the St. Clair Flats, forming the delta at the head of the shallow lake elsewhere described. Up to the year 1856, great inconvenience was felt at this point, particularly at low stages of the western waters, where there was barely six feet of water in some places; and to escape the shoals and shifting sands (which in rough weather were even dangerous), it was the common practice to lighten, at a considerable cost, a part of the cargoes of the ordinary lake schooners.

The attention of the United States and Canadian legislatures was at length success-

fully drawn to the subject, and appropriation was made accordingly, to effect the clearing up, and buoying and lighting of a channel; and since that time, viz., from and including the year 1857, to the end of 1858, the total quantity of dredging done was one hundred and fifty thousand seven hundred and sixty cubic yards, and the channel at the upper end was made two hundred feet wide, the average width being two hundred and seventy-five feet wide.

The channel is now excavated to insure a minimum depth of twelve feet throughout; and in the middle of the channel, for a width of two hundred and thirty feet, the depth is thirteen feet.

The total appropriation to the work was $45,000 from the United States Government, and $20,000 from the Canadian Government, and the work has hitherto appeared to be perfectly satisfactory; and the South Pass is now the master current into the lake.

The material excavated was removed to a distance of five hundred yards from the channel, and re-deposited in the lake. It consisted for the most part of sand, gravel, and mud, with a little hard-pan and drift, corresponding with the drift found on the Michigan peninsula.

The cost per cubic yard was:

Sand, gravel, and mud, ...	$0 30
Hard-pan, or concreted clay and sand, ...	1 50

There are three main channels or passes through the delta, known as the North, Middle, and South Passes,—the latter being the one selected for the operations described, and forming the boundary line between Canada and the United States.

ICE.

The phenomena attending the formation of the ice, and its removal, which form the natural limits to all the economical operations of the people living within the district, deserve especial consideration. During the long winters, in the earlier periods of the history of the country, the people were driven to their homes, without much occupation beyond what was essential to the support of existence. It was a period of four months, with a mean temperature of twelve degrees below the freezing point,—but with extreme fluctuations, of deep snows,—and during which, if they could not obey the same instincts which led most of the animals of this vast region to migrate, they would follow that of others which were fitted for hibernation. It is this curtailment, perhaps, of a third part of the year which has encouraged—if it has not developed—that remarkable activity and change in habits (rapid as the changes of the temperature itself), observable in every person and in every operation, upon the opening of navigation.

Travelling through the Northern country, and the *transportation of goods*, during the open seasons, since the discovery of Canada, were chiefly carried on through the lakes, rivers, and streams, in bateaux, or canoes hollowed out of pine logs,—or in the still more fragile craft, birch-bark canoes,—which were hauled out at rapids and falls, and carried around by the Portage roads to the navigable water above or below, as the case varied.

These brought into action a peculiar class of hardy French-Canadians, with Indians and half-breeds, all known as "voyageurs;" and it is not to be wondered at that the opening of the long-frozen waters is hailed with pleasure, as the commencement of a new existence, in the interior of the country.

The temperature of the lakes and rivers, and of the soil, has been referred to; and the study of a sufficient number of observations would probably enable us to define the general laws of cooling: but all the leading phenomena connected with the advent of winter, and with the well-established but slight moderation, known as the "January thaw," the mode and time of breaking up of the ice, have naturally been long and patiently watched and noted; and as the variations of temperature and their effects on the streams and rivers are again and again repeated, with much general regularity, there is little room for error in taking only a few years' observations for the establishment of the leading general characteristics of a given locality: and the uniformity of recurrence in the phenomena under consideration is one of the most striking features of the natural history of the country.

The average number of days of closed navigation is:

At Quebec,	
At Montreal,	145
Of the St. Lawrence Canals,	135
Of the Ottawa,	
Of the Lake at Kingston,	90
Of Lake Erie, at Buffalo,	130
Of the New York Canals,	134
Of the Welland Canal,	116
Of the Detroit River,	117
Of the Sault Ste. Marie Canal,	156
Of the Illinois and Michigan Canal,	118

The few frosts which occasionally occur early in October, and effect that remarkable change in the color of vegetation so often dwelt on by those who have resided in, or visited, during the "fall," the northeastern portion of the continent, are generally followed by unsettled weather, with occasional heavy rains, and a temperature corresponding to the mean of the year. This is succeeded, early in November, by a slight flurry of snow, and then by a warm and genial season, with an increased degree of moisture in the air, and a

peculiar haze, much resembling our season of early October, in the southern counties of England, and is called, in the transatlantic country, the "Indian Summer." This charming period is suddenly terminated by cold, clear weather, and by about the 25th of November, the still waters become frozen on the surface. Generally by the 5th of the following month, there is a fall of more or less snow, which, while covering with a protective mantle, and retarding the cooling of the earth, aids the formation of the "ground ice," or "anchor ice," in the streams.

The author, having attentively watched the formation of this description of ice, recognizes it as the precise repetition of the same phenomenon in the Thames and Kennet, of England.

The results of his observations in England, on the rivers named, have been supported by similar observations in American rivers, and serve to show that the primitive crystals of ice formed first in contact with the cold air, at the surface of the streams, or derived from snow falling thereon, are carried down, by counter-currents and eddies, below the surface, where they become fastened to the best conducting media. Occasionally portions of the agglutinated mass are broken off by the force of the current, or by other causes,—among which may be, and probably is, the change in the atmospheric pressure, and in the temperature of the stream, and consequent change in specific gravity, which would induce the rising of the mass to the surface; and in the large American rivers this soon takes effect, and the whole becomes frozen into a solid mass of field or surface-ice. Much of the ice, however, is for the time held to the bottom, by contact with stones or a rocky bed, and is then known as anchor-ice. Much travels, rolling slowly along on the bed, loaded with gravel or sand, which increasing the specific gravity of the mass, prevents its rising to the surface.

Soon the small bays and indentations of the banks fill up, and shallows become more effectual barriers to the stream, producing comparatively still waters, which, under the influence of the *all-pervading* cold, with the increased falls of snow, augment the thickness and strength of the floating masses. Then begins an actual blockade, causing an increase in the height of the river, which relieves, for the moment, some of the ice and the pent up water, which flows towards the next retarding point.

In the large rivers this is particularly interesting, and some of its features are really imposing. At Montreal, for instance, the movements are possessed of a certain degree of grandeur. Here the current, before described, flowing between the Northwest Bank and St. Helen's Island, although the narrowest channel, soon becomes the master current; for that which flows through the wider and shallow space, on the south side of the island, although really in the most direct course to the lower reaches of the river, soon becomes almost blocked up. The great discharge of the field-ice, broken up first in the Rapids of

Lachine, is, to a partial extent, reset into floes in the Bay of Laprairie, above the Victoria Bridge, and approaches the St. Mary's current in such masses and quantity as soon to fill up the reaches below, which, by this time, are more or less blocked up by the accumulation of the solid field ice, which commences in Lake St. Peter, and extends for many miles upwards through the low islands and over the shallow rivers between Sorel and Berthier. The next blockade below the city forms at Boucherville, where local circumstances favor its collection. The subsequent filling up of the whole surface of the river, for about seven miles of its course, is rarely the work of three days.

Now the most interesting feature begins to show itself. The ice continues to come down in undiminished quantity and mass, and gradually reduces the channel of St. Mary's Rapid, which results in a rising of the surface to obtain the required discharge through the diminished cross section. Often temporary relief is obtained. The water falls suddenly, and rises again, for like reasons, till at length a uniform "regime" is established. During these sudden rises and falls, the ice coming down with the velocity due to the river, pushes, or shoves, and packs,—rising up and piling itself in mounds on the banks; covering the wharves—already submerged—to the extent of from two to twelve feet; mounts, generally, a retaining wall twenty feet above the ordinary level of the river, occasionally packing and piling upon it, and obstructing the wide front street, with a mound rising in some instances to the eaves of the warehouses, from twenty-five to thirty-five feet high.

In other places, as on the low islands in the river, and in shoals in that part of it opposite the city, the accumulation goes on, while the projecting upstream side of St. Helen's Island receives its share.

Doubtless the discharge of the river is, to some extent, reduced in quantity through the freezing up of streams whose volume is not regulated by lakes on their respective water-courses; and the discharge of the large lakes is also greatly reduced by the obstruction caused by the barrier of ice across their mouths; and where, as the head cannot rise in the like proportion (*i. e.* to a degree sufficient to compensate for the reduction of the hydraulic mean depth of the river at its outlet), the mean velocity and discharge must decrease. Such effect, at least, is perceived at the lower parts of the river, where, in general, from six to ten days elapse after the final taking, and all shoving has ceased. The whole surface then falls, except in those parts where the ice has grounded; for although the ice is, over a good part of the area under consideration, estimated at from ten to twelve feet thick, some portions may be deeper, and actually resting firmly on the bed of the river. There successively appear indications of shoal water; and we may recognize in some of the large mounds on the surface, when it has fallen to its final "regime" of minimum level (which is attained generally in ten days after the final taking), the

shoals and dangers of the navigation,—a sort of parallel repetition and model of the surface of the bottom.

The circumstances which have been here related occur again at most of the Rapids; and there are interesting illustrations every year at Lachine,—on no occasion or place more so than the remarkable shove which took place last December, four miles above Montreal, also at Cornwall, and in other Rapids up stream. Similar effects take effect on the river in the Richelieu Rapids, below Lake St. Peter, which generally rises far above its usual level, and causes considerable inundation in the district above this part of the river, and on both sides of it.

But perhaps the most striking feature of the season is its breaking up, which is generally attended with the same features on even a more extended scale, the average period of this being about the 10th of April; and at Montreal it has been accompanied by many curious effects, of jamming and shoving, and what is more important, by certain occasionally attendant floods, so as to render it a matter of surprise, in spite of repeated warnings, and with a past history of the river, which nature has painted in such distinct and marked lines as cannot be misinterpreted,—that the subject of a remedy has not long since met with more becoming attention from the authorities of the city, especially in the interest of a portion of it extending towards the Lachine swamp, which bears marks of its ancient office, as an important channel of the river.

The breaking up is always accompanied by the shoving, and generally with more or less packing. The photograph accompanying this paper (Appendix, marked 8), illustrates truthfully the evil to be contended with, in a special instance which was observed in 1859. In these movements are tested the value of the cribwork elsewhere described. The wharves being kept low, they are comparatively clear of the moving mass of ice; and if sufficiently loaded with stone, and left with smooth surfaces, no considerable injury results. Instances of the removal of large masses of cribwork, although known, are rare; and where they have occurred, the fact has generally arisen from want of attention to their loading, to their undue height, or to injudicious position or direction of their sides.

The tidal portion of the river occasionally "takes" at the Richelieu Rapids; and in about four years out of five it takes for a few days, at least, and sometimes even for the whole time, in the narrow gorge of the river, opposite Caronge, from six to eight miles above Quebec.

At Quebec the much wished for "taking," and the formation of a "pont," so called, is less frequent; and it seems that one year in four is about the frequency of occasions. When the ice bridge or "pont" exists, the surface is generally frozen for a considerable distance to the head of, and sometimes down both channels of the river at the sides of, the Island of Orleans, from one to six miles.

The navigation at and below Quebec soon generally becomes obstructed through the large accumulation of drift-ice in the tideway, which fills up most rapidly, and sometimes to the extent even of almost the whole surface of the river, for eighty miles down its course, before the end of January.

The manner of its accumulation is chiefly to be observed in the bays and indentations, where accumulations go on increasing until an occasionally higher tide than usual floats large fields of ice into the stream; this, of course, generally drags along the shore of the river, or becomes attached to older drift-ice, or to stones and rocks, which it grinds and rubs to a smooth, rounded, *moutonnée* surface, recognizable on all rocks subjected to glacial action, and a "bordage" accumulates, having a width and thickness chiefly affected and modified in form by winds and tides.

The experiment of landing a detachment of the British army at Bic, in the last week of December, shows that, for practical purposes, the river, although generally open at that point for about a month after the closing of the upper navigation, cannot be reckoned on with any degree of certainty so late as the time at which that landing was effected.

WINTER AND LUMBERING.

The progress of civilization and of trade, however, in Canada, has developed occupations for the farmers in winter, who avail themselves of the frozen rivers and lakes to move heavy loads of produce which could not be carried over the unmetalled roads of this vast district of soft surface clay and marl, and, therefore, winter is now looked for with almost as much interest as the harvest.

The lumbering operations of Canada are almost all performed in the depth of winter, and while there is a great depth of snow, the trees generally being felled when there is from two to three feet of snow in the woods. These are then hewed down to suitable sizes, and hauled out by horses, on the snow or across the ice to the frozen streams, upon which they are moved forward, first singly, then in drams,—a number of which go to form a raft,—and in this state, at the opening of navigation, they travel for many hundreds of miles, down rivers, across lakes, and overcoming rapids by means of slides or shoots, having a slight depth of water to facilitate their movement. The author, however, refrains from entering upon this subject, although it is sufficiently interesting, as including some rather remarkable engineering structures and process of manufacture, affording fitting subjects for a paper which could be better supplied by those who have had long practical experience of this great element of the wealth of the British North American Provinces. Statistics, however, are added, in the Appendix marked 32, which afford very useful information touching the quantity, value, and description of the export of lumber from Quebec for some years past.

METEOROLOGY.

The subject of meteorology has occupied the attention of the physicists of the United States, and the results of observations, collected at a variety of points over almost the whole of the continent, have led to valuable contributions to science in general. The arrangements which were suggested by, and are under the control of, Dr. Henry, of the Smithsonian Institution, at Washington, deserve especial mention; as by means of these exact predictions of coming storms have been made with actual certainty. And this is one of the collateral advantages derived from the electric telegraph ramifying, to such a prodigious extent, over the area of the United States and Canada.

The number of stations at which observations are now constantly taken daily, by order of the United States Government, under the direction of the United States Topographical Engineers, is one hundred and fifty-seven. In addition to these, it is a requirement of the regents of the public schools in the State of New York, as well as in most of the other States, and in Canada, to keep a careful record of general meteorological observations. And in addition to the yearly results which are transmitted to central points (as, for instance, in the case of the public schools of the United States to Albany), a large number of these observations are also placed in daily communication, at a particular hour, with the Smithsonian Institution, where the conductor in charge can see at a glance all that is going on. And as the results of such an extensive system enables the philosopher to test his generalizations, from hour to hour, we may expect very important developments.

All these observations seem to confirm the ideas promulgated by Dr. Henry (who supposes) that the prevalent winds are the immediate effects of the great currents of the ocean, modified by circumstances. It is supposed that the elevated temperature of the water in the Gulf of Mexico,—which is greater than that of the water in almost any other part of the globe,—is retained by the Gulf Stream until it reaches the shores of the polar basin. The southwest winds, which accompany and blow from the Gulf Stream, share its temperature; and we feel the benefits on our English coasts and climate, which is far more genial than would be due to our latitude. The southwest and westerly winds, which prevail over the surface of the United States, serve to bear the heat of the Gulf Stream from the American coast; and when an easterly wind is produced by local causes, which would bring the warm air of the Stream to these shores, it is cooled by crossing the polar current flowing south, next the shore, which reduces its temperature to the dew point, and produces the peculiar chilly effect familiar to the inhabitants of the Eastern States and Canada; while on the Pacific Coast, the west winds from the ocean cross the comparatively cool current from the north, and impart a uniform temperature to the western

slope of the Coast range of mountains, giving rise to the equal summer temperature so frequently described as prevailing on that coast.

Were the whole of North America, from the Atlantic to the Pacific, a continuous plain, and were the surface diversified merely by eminences of comparatively small elevation, the moisture from the Pacific would be carried into the interior, and a much greater degree of fertility in the western portion of the Valley of the Mississippi would exist. In the actual condition of the continent, however, the westerly wind which passes over the great mountain system which extends from north to south, along the western portion of the continent, deposits its moisture principally on the western slope of the Coast range, and gives fertility and mild climate to California, Oregon, Washington Territory, and to Vancouver's Island, and the British possessions further north. Such moisture as may remain is precipitated on the western slopes of the high ridges of the Rocky Mountains, further east; and the air becomes almost completely desiccated, leaving the elevated plains east of the Rocky Mountains an arid region, and so deficient in moisture as to be unfit for cultivation, unless by the aid of irrigation. Such is the united testimony of all those who have returned from the exploration of the open country between and away from the streams which occasionally form little oases in the great desert.

So remarkably is this the case, that it has been stated in general terms that if a prime vertical line be drawn from about the longitude of ninety-eight degrees west, striking the Gulf of Mexico, we divide the continent of North America into two nearly equal portions; that to the east being the cultivated and valuable agricultural portion of the country,—that which lies to the west, with the exception of a few isolated spots, and with the exception, also, of the western slopes of the Coast range of the Rocky Mountains, being, for the most part, an arid wilderness.

It is considered that there are two great systems of wind prevailing over the United States,—the upper from the northwest, and the lower from the southwest; the latter carrying the moisture from the Gulf of Mexico and the Caribbean Sea over the whole of the eastern States of the Union, and the eastern part of the Valley of the Mississippi, and being, therefore, the principal fertilizing wind of the interior of the continent. Were the earth at rest, this wind would flow directly northward, and would divide its vapor over the whole of the interior of the country, to the base of the Rocky Mountains; but on account of the rotation of the earth it is drawn eastward, and bears its moisture in a northeasterly direction, leaving a large space, as it were, under the lee of the Rocky Mountains, greatly deficient in this element of vegetable production.

A small map is appended to this paper, showing the general direction of the winds. The green portions of the map indicate the naturally woody regions of the country, well supplied with water from the fertilizing winds. The pink-shaded parts indicate rich,

arable prairie, along the streams through which, where there is a local supply of moisture, wood is found, but yet the whole has much less moisture than the naturally woody portions. The uncolored, or white portions of the map, within the boundary of the United States, indicate the regions so deficient in moisture, that no dependence can be placed upon them in regard to agriculture. In some parts of them, where moisture is found, crops may be produced; but as a whole they are of little value in the way of affording the necessaries of human existence, and are incapable of maintaining more than a very sparse population.

For so much of this map relating to the United States, and as an authority for the statements now made, the author is indebted to Dr. Henry.

The author has added to this statement the result of four years' observations upon the rain-bearing winds in Canada (Appendix, No. 9), by which it appears that out of the whole quantity of rain which fell at Montreal, during the years 1858, 1859, 1860, and 1861, the following proportions were derived from the west, northwest, and north, namely: 1858, 28 per cent.; 1859, 36 per cent.; 1860, 28 per cent.; 1861, 30 per cent.; giving an average for the four years of 30½ per cent., while from the other points of the compass during the same period, the average was 67½ per cent.; showing immediately the direction and tendency of the rain-bearing winds, which, while their duration is limited to only a very few days in the year, furnish about three-fourths of all the rain and snow precipitated.

The result of a series of observations on the daily maxima and minima ranges of temperature is appended hereto (Appendix, No. 9), and the diagrams for the years which have been mentioned are given in full, showing results confirming what must have struck the most general observer of the weather in the Valley of the St. Lawrence, viz., *the most remarkable and sudden fluctuations in temperature*, and in the proportion of cloud.

The two features have been projected upon the same paper, and will be studied with interest, if not on account of the particular feature mentioned, yet in regard to the more salient features of actual temperature and its extreme fluctuations. (Plates IV, V.)

Observations have been established at several points in Canada; but before arriving at any generalizations, observations would require to be continued for a much longer period. It has, however, been observed in Canada, as in those parts of New York lying contiguous, that the temperature of the months increased from the first half of February to the last half of July, from which it regularly returns to its minimum in February, as shown in a diagram before referred to. The mean of the second half of April, and of October, in the general group of observations, differs but little from the annual mean.

Lakes or large bodies of water are found to exert an equalizing influence on the tem-

perature; and at twenty-two stations at which the mean annual range is below that of the whole district, all but one are in the vicinity of lakes or rivers.

As compared with Europe, easterly winds bear the same relation to the rains that westerly winds do on our side; for in each case the humid air from the Atlantic is brought over the continent, where, upon cooling, it must precipitate its moisture. In the Northern United States and Canada, northeasterly storms are proverbial for their inclemency; whereas northwesterly winds, bringing air from which the moisture has been previously condensed, have a chilling, but not a rainy character.

A statement of the quantity of rain, as observed at a variety of stations, is given in the Appendix, No. 9; and to add to the value of those observations taken in Canada, the result of observations made in the State of New York is also given.

It will also be seen that the last rain in the State of New York appears to fall in the valley of the St. Lawrence, and the western portions of that State; and, therefore, the region of the great lakes receive a rain fall below the general average.

The rainy season is greatest in summer and autumn during the prevalence of ocean winds, and, coincidently, it is least in the spring and winter, when the land winds prevail. The least depth of rain, including snow (eight inches of which are assumed to equal one inch of rain), falls in February, the greatest in June; the quantity falling in August being nearly equal to the annual monthly mean. From May to November it is greater, and during the remainder of the year it is less than the general average.

The relative forwardness of the seasons may be best obtained by referring to a statement of the duration of closed navigation at various points, given at page 265, under the article "Ice."

With respect to the temperature of the waters of the valley of the St. Lawrence, the writer is not aware of any other continued observations than those which have been made in the River St. Lawrence, at Montreal.

The observations recorded by Mr. Hodges, in his elaborate description of the Victoria Bridge, and its works, contain some interesting matter relating to that feature of the St. Lawrence.

In order to render the subject more complete, the writer has given below the result of one year's observations on the mean temperature of the water, and the mean temperature of the air, taken at two stations, at 9 A.M., noon, and 3 and 6 P.M., for the year 1861, near to the city of Montreal. These results show that the mean temperature of the year was 45.03°; that the mean of the air, during November, December, January, February, and March, 151 days, was 24.20°; that the maximum was 47.50°, and the range 76°; and that the number of days at and below zero was 16; at and below 32°, 113; and at and below 24.20°, the mean, 75. That in the next period,—April, May, and October,—92

days, the mean was 49.23°; the maximum, 73.50°; the minimum, 21.50°; the range being 52°; and that at and below 32°, there were 8 days; at and below 49.23°, 58 days; at and above 60°, 19 days; at and above 70°, 3 days.

Of the remaining 122 days, namely, June, July, August, and September, the mean was 67.91°; the maximum, 91°; the minimum, 45.50°; the range, 45.50°. That at and below 50°, there were 4 days; above 67.91°, 86 days; at and above 80°, 14 days; at and above 90°, 3 days. The total number of days in the year below 32°, was 121; the extreme range of the year, between 9 in the morning and 6 in the evening, was $119\frac{5}{10}$°; in any 24 hours in the summer, was on July 10th and 11th, 20.50°; and in winter, January 10th and 11th, 38°. The mean temperature of the water, during the year, was 45.80°; the mean of the month of August was 69°, and of January, 30.50°. And the records show that the temperature of the water for four months, namely, January, February, March, and December, were, respectively, 30.50°, 30.55°, 31.20°, and 31.90°. The extreme range of the temperature of the water was 46°,—its maximum temperature was 75°, on the 5th of August, and the minimum 29°, on the 8th of February, on which day the minimum atmospheric temperature was also observed.

The mean temperature of the soil has been observed, for a considerable period, at Burlington, in Vermont; and also at Dr. Smallwood's Observatory, at Isle Jesus, near Montreal; and the mean temperature, at four feet beneath the surface, is stated to be 44.70°. The majority of deep springs which have been observed by the author give a temperature of 44°.

Valuable experiments have been made by Dr. Emmons, at Albany, upon the temperature of the soil, and published in the Reports of the Natural History of the State of New York. These will be studied with interest, in connection with the agriculture of the country. The developments of the curves of temperature give results in a very striking manner.

With respect to the penetration of the frost into the ground, much depends upon the nature of the soil, and character of the vegetation, or the depth of snow which covers the surface of the earth. But as a general rule, for the guidance of engineers in the country, it is stated that no water-pipes are safe at a less depth than four feet; and at this depth there were many indications of frost during the existing winter, in the trenches prepared for gas and water-pipes, in the city of Montreal.

TEMPERATURE OF THE LAKES.

The mean temperature of the deeper parts of Lake Champlain, in winter, is said to be about 40°; and while the surface is covered with ice, it changes very slightly. In the

shallow part of the lake, near its southern end, and where the volume is but small, the temperature is very little above the freezing-point for some weeks, but in the deeper parts of it, the water rarely falls below 40°. The mean temperature of the earth in Vermont, contiguous to the lake, has been observed to be about 45°; and it is not surprising, therefore, that so soon as the cooling influences of the severe winter of this region have been mitigated, the large masses of water should first break up, and very rapidly convert the ice; and in support of this view, it may be remarked, that the latest disappearance of ice may be almost always reckoned on in the comparatively shallow exposed surfaces of the smaller lakes and ponds of the country.

Nor, under the circumstances, is it a matter of surprise that these large masses of water, these inland seas of the country, should exert a certain influence on the atmosphere surrounding them; and it has long been a matter of general observation, but is now reduced to the most tangible form by Dr. Henry, of the Smithsonian Institution, at Washington, who has given the results of the observations established throughout the United States and Canada, and which I have elsewhere referred to at length; and the deflection of the general direction of the mean isothermal lines of winter and summer, as given on the map, shows the modifying influences of the large masses of water in the central and western parts of Canada.

Experiments are wanting to show the temperature of the large upper lakes in winter: these would probably afford most interesting results.

Except in creeks, and small harbors and bays, these are never frozen much beyond the bordage of broken ice, which varies in width from a few yards, as in the case of deep water against bluffs, to a mile, or occasionally two miles, under circumstances favoring its accumulation; and hence it is that the cooling of large masses of water having such profundity as Lake Huron and Lake Ontario, is carried on to even a lower point than occurs in the case of the smaller lakes, and some shallower lakes, where the smaller extent of surface to be ruffled by the winds, admits of the early formation of a protective covering of ice.

Observations have been made by the officers of the United States Topographical Engineers during the progress of the lake surveys, and show very interesting results as to the temperature of the lakes: for instance, on Lake Erie, in the middle of August, 1845, the mean temperature of the air at noon was 76°; that of the water at the surface was 73°; while the temperature of the bottom was 57°, the depth of the lake being 76½ feet. In another instance, while the temperature at the surface was 71½°, that of the bottom, at 81 feet, was 58°; at double the depth, the water on the surface being 73°. Experiments were made at the end of July, 1860, midway in the lake between Cape Hurd and

Duck Islands, when it was found that while the air was 64°, the water showed 52° at surface, and 42° at 100 fathoms depth.

The fact of the existence of the cooler water being always available on Lake Ontario, has long been known to those who navigate the lakes; and advantage is constantly taken in summer of the means always within reach, to obtain a supply of cool water in a vessel let down for a few minutes to the depth of a few fathoms below the warm surface water of the lake.

FLOODS.

Attention has been drawn to the remarkable absence of floods in the River St. Lawrence. Although those in the Ottawa are felt, yet they rarely exceed seven feet in the greatest instance, the whole basin forming an exception to the general rule of all North American rivers. In fact, taking the St. Lawrence River proper, from Lake Ontario downwards, it is most remarkable that, except under the influence of the packing of the ice (the effects of which are elsewhere explained), the floods in the river, due to freshets, are scarcely perceptible; the extreme fluctuation which generally takes place in the months of April and May being about two feet two inches above the normal level. This is, of course, due to the compensating effect of the great lakes, the area of the rivers themselves, and the uncounted lakes and swamps scattered over the whole of the basin on the slope of the northern side of the drainage area. And it is not a little remarkable that these lakes appear to be most numerous in the Laurentian system. The same feature is observable in the Adirondack region, which is also full of streams and lakes, many of which are found at seventeen hundred to eighteen hundred feet above tidewater at the head of the Moose River, and the Black River, naturally draining into Lake Ontario, at Sackett's Harbor, and lying closely contiguous to the head waters of the Scroen and Mohawk, flowing to the Hudson, and those of the Raquette, which drains into the St. Lawrence, at Cornwall.

A glance at the map will suggest the contrast which the author now begs to make in reference to the drainage of contiguous basins.

If we examine the basin of the Ohio (the southern neighbor of the St. Lawrence), draining the northeast portion of the Mississippi basin, and having its source from five hundred to one thousand feet above the level of Lakes Ontario and Erie, the dividing ridge not averaging thirty miles away from the shore of both of them, and having an area of about two hundred thousand square miles, one is struck with the remarkable contrast in its discharge. The river flows for its entire length (about nine hundred miles), in its low state with a gentle current, unintercepted by rapids, except at the Falls of Ohio, near Louisville, where there is a sudden fall of twenty-six feet in three miles; and it is during

the summer season a scanty, shallow stream, a succession of long pools and ripples, with a current alternately sluggish and rapid, with bars in the upper part of it consisting of gravel, and in the lower part of shifting sand.

The rain fall of the Ohio Valley may, perhaps, slightly exceed that over the average of the St. Lawrence Valley, as far as we have the means of calculating (the average fall over its area being, perhaps, fifteen per cent. more than that of the St. Lawrence basin); yet the range between extreme low and extreme high water is about forty-five feet throughout the river. At Wheeling, Virginia, eight hundred and ninety miles above its junction with the Mississippi, it is forty-five feet; at Louisville, forty-two feet on the Falls, and sixty-four feet below them; at Evansville, forty feet; at Paducah, fifty-one feet; and at its confluence with the great Mississippi, fifty-one feet. The usual range does not exceed twenty-five feet. The usual rise in the Ohio takes place in February, and occasionally as late as March. This arises from the melting of the snows, and generally amounting to twenty-five feet; the river remains high for about six weeks. Another rise takes place in May, or June, due to the summer rains, lasting from three to four weeks at Cairo, and from one to two at Louisville. In October, the lowest stage is obtained, when it is navigable chiefly for boats of eighteen inches draught; but in November, the river generally begins to rise, and continues to do so until the banks are full. These floods are due to the autumn rains, which are sometimes continued as late as the end of December.

The author is indebted for the foregoing information to a very valuable report, prepared by General A. A. Humphreys, of the United States Army,—a document which has been prepared with the utmost care, and which is calculated to take a prominent position in the literature of our profession relating to hydrodynamics, not only on account of the importance of the questions which are here reported upon, but also on account of the large amount of knowledge it contributes respecting the Mississippi Delta.

FLUCTUATIONS OF LEVEL IN THE ELEVATION OF THE SURFACES IN THE GREAT LAKES.

It cannot be surprising that suppositions have been entertained as to the existence of tides upon these large masses of water; and we find in the "Relations des Jesuites," recorded in the very interesting correspondence sent to France, between 1660 and 1680, frequent references to the subject. Later than that the subject was noticed by Dr. Weld, in his travels in Canada, from 1790 to 1795, who stated that it was believed by many that the waters of Lake Ontario were influenced by a tide ebbing and flowing frequently

in the course of twenty-four hours; and he instances the fact of its rising and falling fourteen inches every four hours in the Bay of Quinte. Other writers, as well as observers, have altogether denied the latter statement, and have attributed the remarkable fluctuations which occasionally occur on Lake Ontario, and on Lake Huron, to other causes; and have not hesitated to ascribe them to partial and local changes in atmospheric pressure.

But it was impossible to dispute the fact of great fluctuations existing over a long period, the range of rise and fall in which has occupied several years to complete. And all this will be apparent by reference to a document which has been compiled by Colonel Whittlesea from undoubted facts, the greater part of them having occurred within the memory of persons still living.

The fluctuation, as may be supposed, is a matter of extreme importance to the various interests which have sprung up on the borders of the lakes, and the great rivers connecting them, but to none more than to the canal interests, as in the case of the Erie Canal, at Black Rock, the supply to which canal is derived through its uppermost reach, direct from Lake Erie, and in which the extreme fluctuations that occurred, as recently as in 1853, caused very considerable anxiety to the managers of that canal; and the relief from which was only to be found in the deepening of the whole of the canal for about twenty-two miles, the greater part of it through a limestone cutting.

As to the causes of this class of fluctuations, a great variety of suggestions have been thrown out, and, as it appears to the writer, some degree of unnecessary difficulty suggested, as to the explanation of the causes, which we should probably find little difficulty in explaining, and even of predicting the fluctuations, if suitable arrangements existed for obtaining data by a sufficiently extended series of observations upon the quantity, the rate, and the time of the fall of rain and snow, and of all the other meteorological phenomena which affect the conversion of the snow into vapor or water. It would be necessary to record the prevalence, direction, and continuance of the winds, which are observed to produce the most extraordinary effect on the surface of these lakes, and to which attention has before been called. And, lastly, should be observed the manner and the form of the taking of the ice at the outlets of these great lakes.

This latter feature appears to have been almost entirely overlooked in the suggestions which have been made to account for the increase or decrease of level in the lakes. But it will at once be apparent that the existence of a broad belt of ice over the whole surface of a rapid river, running at the rate of from three to four miles an hour, must have a great effect in regulating the discharge of that river, and so far modifying its surface. For instance, as at Fort Gratiot, at the foot of Lake Huron, where the river is about nine hundred feet wide, and usually runs at the rate of about three and a half miles per hour

(the depth being about forty-five feet), through about half a mile of its course. The river, also, for several miles below, has about double the width mentioned, and is from twenty-five to thirty-five feet deep, with a fall of about six inches per mile, producing a surface velocity of 1.45 miles per hour. The flatter surface last mentioned is generally covered with ice throughout the winter, but the rapid at the lake outlet is rarely covered more than once in five years. And under these circumstances, it will be observed that the hydraulic mean depth will be reduced from forty to forty-five per cent., by addition of the coating of irregular masses of ice forming the surface, which thus adds to the wetted perimeter, our divisor in hydraulic calculations.

The same facts have been observed to take place at the discharge of Lake Erie, near Buffalo, which is described by Major Lachlan, in the Canadian Journal, of 1854, at the breaking up of the ice of that year, as having had the effect of reducing, for forty hours, the discharge of the Niagara River, so as (according to other testimony), to have reduced the apparent discharge of the cataract by at least one-half, and on which occasion operations were carried on by the mill-owners, on the American side of the river, far out into the stream. The writer also observed, in September, 1857, a rise of two feet nine inches in the level of the water at the Ferry wharf, below the Falls, which took place in the course of one night. This result was not due to rain, nor to any other circumstance, but the continuance, for about twelve hours, of a heavy gale from the southwest, which had the effect of raising the head, and thus increasing the discharge through the rapids at Buffalo, so as to require the additional head of two feet nine inches, in the reach of the river, immediately below the Falls, to enable that deep section of the river between the Falls and the Suspension Bridge, to carry off the increased volume.

The writer by no means desires to imply that all these fluctuations in levels are to be explained by the effects of the accumulation of ice, or by its entire absence; as it is obvious that these only form one of the many circumstances which regulate the very interesting phenomena to which reference has been made.

It will be observed from the facts above stated, that notwithstanding the extensive area of these great lakes, which act in general as compensatory reservoirs, in equalizing the discharge to an almost uniform quantity; yet there are times, as before explained, when an excessive discharge, as well as the reverse action, will introduce abnormal conditions which would have to be eliminated in any calculations of actual quantity; and it may be stated, as an interesting fact bearing on this subject, that the rise of water, to the extent of one foot, on Lake Huron, for about twenty hours, in the summer of 1858, appears to have affected the discharge of the whole of the River St. Clair, the Detroit River, and the intermediate Lake St. Clair, throughout its length, the increase twenty miles down having been about seven inches, and at Detroit two and three-quarter inches: the central surface

velocity at the point first mentioned being increased from three and a quarter to six and a half miles per hour.

Up to the present time there have, unfortunately, been very few opportunities of obtaining these observations by any special scientific or professional investigation.

The fluctuations in these lakes have of late formed the subject of very careful investigation and daily observation; and ever since the establishment of the canals, records have been kept from which it is easy to describe the curves of fluctuation. Colonel Whittlesea, of the State Survey Department, at Cleveland, Ohio, has given much attention to the history of water-levels, as far back as 1788; and the results of modern observations, and of all his own inquiries, which seem to embrace everything that could be collected from trustworthy sources in the United States, are given in a very valuable memoir by that gentleman, published in the Smithsonian contributions, dated July, 1860.

But Mr. Whittlesea, like most others who had considered the probability of a tide existing in these lakes, appears to have failed to discover direct evidences of a flux and reflux that could be connected with the moon's motions.

Such observations, however, from the fitful state of the weather over the whole of this region, would require unusual attention and fitting opportunities for observations with most critical accuracy, for which is required the aid of appliances, and a residence for some time on the spot, to determine and estimate the quantities, which necessarily could only be small. And it is not surprising that those who, like Mr. George C. Davis, and Mr. Jonathan Carver (who were probably but ill supplied, in 1766, with suitable instruments for exact observation), failed to observe any diurnal flood and ebb in the upper lakes.

It remained for Lieutenant-Colonel Graham, of the United States Topographical Engineers, in charge of the works on Lake Michigan and Lake Superior, positively to affirm the existence of the truth which was first stated by him in November, 1858. Since that time the subject has been steadily occupying the attention of Colonel Graham, and of his staff; and the results are given in the report of the Topographical Bureau, for the year 1860 (dated September 30th). The course of the observations has included the recorded ordinates of a curve indicated by tide-gauges; and the discussion of these variations has included a very careful examination of exact meteorological records, in conjunction with these phenomena. The result may be stated broadly, that at Chicago, on Lake Michigan, there was a semi-diurnal spring tide of $\frac{254}{1000}$ of a foot, and a semi-diurnal mean tide of $\frac{153}{1000}$ of a foot. Similar observations conducted by Captain Meade, of the United States Topographical Engineers, show that in Lake Superior, at Superior City, the semi-diurnal spring tide is equal to 0.169 of a foot, and the semi-diurnal mean tide to .087 of a foot. This quantity is, of course, very small, and beyond a scientific interest, is of no practical

value in an engineering point of view; for the other fluctuations, arising from winds and other more apparent and proximate causes, frequently eclipse and altogether conceal them. But it is a remarkable fact; and it is believed that such fluctuations, taken in connection with exact observations upon the specific gravity of water, would tend to the solution of the problem of the moon's mass, or of her density. And it is to be hoped that, in the interest of science, similar observations may be undertaken in other lakes, in different parts of the world, where, as for instance, in the Caspian Sea, which is the largest lake in the world, and which has no regular outlet, it is believed that valuable information could be usefully collected.

THE OTTAWA.

The Ottawa is a magnificent river, having three points of confluence with the St. Lawrence; one passing by Vaudreuil, entering at the foot of the Cascade Rapids, another by St. Anne's, at the upper part of Lake St. Louis, about twenty-four miles above Montreal, and the third opposite Varennes, thirty miles below that city. The northern stream (which flows to the north, and thus insulates the district of Montreal), bifurcates near the village of St. Eustache, and further insulates the district of Laval, known by the name of Isle Jesus. The two reuniting once more close to the lower confluence with the St. Lawrence, both branches of the river pour down their brown, peaty-colored waters, and stain the northwest side of the St. Lawrence nearly into Lake St. Peter, the blending there being favored by the various currents induced by the low alluvial islands occupying the river, which is about six miles wide (between Sorel and Berthier).

From St. Anne's, passing up the Ottawa, we pursue an almost westerly course to Ottawa, one hundred and ten miles above Montreal, where the Fall known as the "Chaudiere," interrupts the navigation: the Fall itself, with six miles of rapid water above it, having a total descent of sixty-seven feet.

In that part of the river now described, the Ottawa receives many very important affluents from the northern side, draining the front and the vast plateau in rear of the Laurentian Hills. The chief of these are the "Du Lievre," and the "Gatineau;" the latter joining close to the town of Ottawa, and having its sources as far north as the forty-eighth parallel, its head waters lying closely contiguous to the head waters of the St. Maurice and the Saguenay. A very limited extent of settlement has been carried out in this direction, and the region is comparatively unexplored and unknown,—still less surveyed; although those who have crossed it in various directions report it as being filled with uncounted lakes, which regulate the annual supply to the rivers of the whole of this vast region.

The affluents on the south side are the Petite Nation, and the Rideau Rivers; the head

waters of the former draining back into the country, within nine miles of the main stream of the St. Lawrence, at Prescott, where its head water is forty-nine feet above it, and about ninety feet above its confluence with the Ottawa. The line of the main channel of this small stream extends its tortuous course through deep alluvial soil, for upwards of a hundred miles, passing through and producing swamps which have the same effect, to a certain extent, as the lakes on the northern side. The Rideau River has proportionately a very large drainage area, filled with lakes and streams flowing chiefly from, and determined in outline by the outcrop of the Laurentian formation, which has been described as sweeping down from the Chats Falls to the Thousand Isles, near Kingston.

Above Ottawa there is rapid water extending for upwards of six miles, and from this point the stream, although less direct, passes on in the direction of the northwest, over and through a wilder country of the Laurentian Hills, with heavy forests of pine and other timber extending down to its very margin. The irregular and tortuous channel, swelling occasionally into deep, wide lakes, terminates immediately above Allumette Island; and from this point the river, taking a slight bend once more in a west-northwest direction, pursues its course through a series of long reaches, separated from one another by short, abrupt falls or rapids, with a tolerably uniform width and depth, as far as the affluence of the Mattawan; then turning to a direction almost northward, it is described as terminating in a series of lakes, the largest of which, in the direct course of the river, is "Temiscaming," "Tamagaminque," and "Grand Lake;" the one lying some distance to the west, and the other about as far to the east of Temiscaming, pouring their waters into it by the "Montreal" and "Moose" Rivers respectively, and the drainage occupying the whole district lying as far north as the forty-ninth parallel, and generally separated from the drainage into the river below Ottawa by the meridian of seventy-six and a half degrees. The affluents upon both sides of the river, for the portion west of Ottawa, are much more numerous, and are all very much smaller than the streams previously mentioned. On the north side they consist of the "Colonge," uniting close to Portage du Fort, the "Du Moine," the "Bear," and the "Kippeway." On the south side, the chief of these streams are the Mississippi, the Madawaska, the Bonne Chère, the Petawawee, and the Mattawan. These drain a vast extent of Laurentian formation, covered for the most part with heavy pine timber, the district of the chief lumbering operations in Canada at the present moment. The country is very much broken, and the bottoms of its valleys and creeks are occupied by numerous streamlets and lakes lying at elevations extending up to fourteen hundred feet above tidewater; at which elevations may be found the sources of the streams last mentioned, draining into the Ottawa, and the head waters of the Maganatawan, flowing into Lake Huron.

One tributary, on the right bank of the river, unites with the main Ottawa, at Matta-

wan, the point of northern divergence just mentioned; and it is important as being the favorite route of the early voyageurs in their journeys to Lake Huron and Lake Superior. Starting from the Hudson's Bay Post, at its confluence with the river, the Mattawan is traceable in a course generally westerly, through five or six small lakes, terminating in Trout Lake, which is the head of the drainage in this direction, and about six hundred and fifty-nine feet above the sea.

Among the various schemes which have been proposed for the improvement of the navigation between the upper lakes and the Atlantic, that of Mr. Shanly, which is gaining (and perhaps deservedly) the most favor, is one which proposed, after improving the River Ottawa, up to the mouth of the Mattawan, to follow the line of this tributary up to its head water in the Trout Lake. From this point it is proposed to lock down into Lake Nipissing, which is only about twenty-three feet below it, through the valley of the "Vase." Lake Nipissing, which receives the drainage of the "Sturgeon," the "Namanitigong," and other rivers, with that of numerous lakes, at their several head waters, communicates with the Georgian Bay, through French River; the length of the river being about sixty miles, and the descent, effected in a series of weir-like falls, sixty-four feet.

The entire distance from the Georgian Bay to Montreal, by the route which has now been described (and which, of course, includes improvements of the river to overcome the falls at Ottawa, the Chats, and other points of interruption, as well as the reconstruction of the small canal near Carillon and Grenville), being four hundred and thirty miles. The lockage upwards from Lake Huron to the summit would be eighty-seven feet, and the fall downwards would be six hundred and nineteen feet, to the harbor of Montreal.

And having now generally referred to this enormous river, a full description of which might have occupied a far more extensive space,—and having mentioned the proposal to improve the water communication, by a more direct route, between the upper lakes and the Atlantic, it is only proper to draw attention to another project, with the same object in view. This consists of a canal commencing at the level of Lake Huron, near Nottawassauga Bay, passing through part of the Valley of the Muskoka and of the Severn, which constitute the drainage of Lake Simcoe, into Georgian Bay. It is proposed to make Lake Simcoe, which is one hundred and thirty feet above Georgian Bay, the summit level; and cutting through the dividing ridge, to a depth of two hundred feet, lock down its southern slope, four hundred and seventy feet, into Lake Ontario, near Toronto. With regard to both of these plans, however, little has been done beyond preliminary surveys. The expenditure by the last-named route is estimated at $24,000,000; that by the Ottawa route at about the same amount, including the further widening of the Lachine Canal.

Taking Chicago and Montreal as common points, and comparing both with the Welland Canal, the following would be the position of affairs:

	DISTANCES FROM CHICAGO.				LOCKAGE.		
	Miles. Lake.	Miles River.	Miles. Canal.	Miles. Total.	Up.	Down.	Total.
No. 1. Welland Canal, Lake, and River, . .	1,145	132	71	1,348		535	535
" 2. Toronto and Georgian Bay, ...	775	155	120	1,050	130	675	805
" 3. French River and Ottawa, ...	575	347	58	980	87?	619?	706

From which figures it appears that in point of distance No. 3, namely, by the Ottawa, holds a very wide advantage over both the rival routes, and is also superior, in point of lockage, to the Georgian Bay route. And if constructed, it would be yet more important in a sense which just now would seem to be of the greatest consequence, namely, the national consideration. For a glance will show that the communication with the West would no longer occupy almost the very line of the frontier between the United States and Canada, through a considerable portion of the route; and where the locks of the canal, which are such important and vulnerable points, approach so near to American territory.

CANALS OF CANADA.

The system of canals which were exclusively undertaken, or are controlled, by the Provincial Government of Canada, consists of a series of works for overcoming the Rapids, on the line of the main discharge of the waters of the upper lakes through the St. Lawrence Valley; secondly, in improvements of the same nature applied to the Ottawa River; thirdly, in a connection effected by a cross canal between the Ottawa River and the city of that name, with the River St. Lawrence, at Kingston, which is at the outlet of Lake Ontario; fourthly, of improvements on the Chambly, or Richelieu River, which is the outlet of Lake Champlain. There is, also, a series of minor improvements in the form of locks, or very short canals, in the district occupied by the line of lakes extending almost parallel with the north shore of Lake Ontario, from Lake Scugog by way of Peterboro' and the Trent River to Trenton, at which place the Trent discharges into the lake.

As for the purposes contemplated in the present contribution to the information of the Society, it would far surpass any reasonable limits, to describe with the requisite full engineering details, each canal with its peculiarities. An attempt has been made to tabu-

late, and to offer in one view a statement, with all the leading features which are likely to render this paper of interest and value; and a broadside sheet marked 12, was prepared, intended to give under the head of details of construction, first the name and object of each work, the dates of its commencement and completion, the total cost up to January, 1861, the nature of the supply of water, the length with a diagram of the cross section of the canal, as constructed, the number, the length, the cross section and the lift of all the locks, with particulars of minimum structure. Under the next head was shown the working capabilities of the canal, with the limits of the length, beam, and draft of vessels that can pass the locks, the time of transit at each lock, and for the entire passage of the canal, and the number of working days on the average in the year. And under the head of traffic was given the number of vessels up and down; the number of tons carried up and down; the particulars of the haulage, how performed, and the cost; the total revenue of the canals, and the expenses of repairs and maintenance; the tolls per ton, and the total amount of tolls charged.

The first of these great improvements was commenced about the year 1819, by a private company, which undertook the construction and completion of the Lachine Canal, which proposed to overcome the Rapids from Lake St. Louis down to Montreal, the total length of fall being four thousand three hundred and seventy-five feet.

This canal commenced in the St. Lawrence River, at a place called Windmill Point, and near the upper end of the present harbor, at Montreal. One of the original locks still remains at this point, and the dimensions are one hundred and twenty-six feet by twenty-four.

The line proceeds across a marsh for about four miles, and eventually passes into more solid ground, and terminates in a rock of the Trenton group at Lake St. Louis. The number of locks originally was *nine*.

Following this great improvement, which at once overcame the most considerable difficulties in the inland navigation, some improvements were commenced on the River Ottawa, consisting first, of the St. Anne's lock and dam, to overcome the Rapids of St. Anne, at the entrance to the Ottawa River, about twenty-four miles west of Montreal.

The length of the entire work is about half a mile, and the fall, which is on the average about three and a half feet, is overcome by one lock one hundred and ninety feet long and forty-four feet wide. At Carillon there is a small lockage, consisting of two combined locks rising twenty-three feet to pass over a small summit (the cost to cut through which was considered too expensive), and one single descending lock 12.93 feet; so that the actual fall surmounted at this point is only about ten feet. The length of the canal is about $2\frac{1}{10}$ miles. The Chute à Blondeau is the next canal, and closely contiguous to the former one; its length being about one-sixth of a mile, overcome by one lock surmounting

a lift of three feet ten inches. The Grenville Canal, still further up stream, is a canal having the same object, five and three-quarter miles in length, having six locks, overcoming a lift of forty-six feet: the total lift for the three canals being 72.88 feet ascending, descending 12.93 feet, or 59.95 feet.

All locks upon the system last mentioned have a depth of five feet upon the sills, are one hundred feet long, nineteen feet wide, and were constructed before the year 1833.

The Rideau Canal, of which there is a very full description given in an elaborate paper by Lieutenant Frome, late of the Royal Engineers, in the R. E. papers, is a work of considerable importance, and was constructed at a very large cost by the British Government. It was commenced about the year 1826, and completed about 1831. Its supply of water is from the Rideau Lake, from which lake the river flows in a general northeasterly and southwesterly direction. The length of the canal is about eighty-four and a quarter miles. Its cross section is forty-eight feet wide at the top, twenty-eight feet at the bottom, with five feet depth of water. There are thirty-three locks, one hundred and thirty-four feet long, thirty-three feet wide, and the depth on the sills is five feet. The greatest lift is fourteen feet six inches. With regard to the construction of the canal, it was carried on under the direction of Colonel By, whose name first characterized the locality of the city which has been chosen as the future seat of government in Canada.

The paper to which allusion has been made will have afforded to engineers some interesting information, and an account of difficulties of no common occurrence. It is to be regretted that the course of trade, which of late years has rather tended by the more direct route up the St. Lawrence, has appeared to demand less of that attention to the maintenance of the works on this navigation than its importance in a national point of view seems yet to demand.

Details of the traffic carried on this canal, are given in the trade and navigation returns of Canada, by which it will be seen that the traffic through this district is of very considerable importance. The works now described would include all the works undertaken up to about the year 1819; and previous to which time, the attention of the authorities in the State of New York was directed to the importance of bringing down a line of canal connecting Lake Erie with the tidewater navigation at Albany, a work which was proceeded upon with great alacrity, and completed with that degree of energy, which appears to characterize the people of the Northern United States.

To this canal, and its works, reference is made in another place. The effect on the minds of the public men in Canada was immediately to provide for the carrying out of a work, which is the most important of all those that have occupied the attention of the public in Canada, namely, the construction of the Welland Canal. This work intersects

the barrier which separates, and maintains the difference of level between Lake Erie and Lake Ontario, the natural discharge of the former being by Niagara River and Cataract.

The work consists of a reach of canal extending from Lake Erie to the head of a series of lockages overcoming a lift of three hundred and thirty-one feet, which, as shown in the section, are grouped rather closely together on the rapid descent through the villages of Thorold, St. Catharine's, and Port Dalhousie. The entire length of the canal is twenty-eight miles, in addition to which there is a feeder of twenty-one miles in length, derived from the Grand River, which is dammed up to the extent of seven feet, for the purpose of affording a steady supply of water, as well as of avoiding an expensive difficulty in construction by extending the depth of the excavation, which has been a constant source of trouble, but it was, perhaps, the more desirable, in consequence of the extreme fluctuations which take place in the level of Lake Erie. The chief work upon this canal is the Summit Level Cutting, cut through the Niagara limestone, which has caused very considerable difficulty by slips and slides. The locks, twenty-four in number, are one hundred and fifty feet long, twenty-six feet six inches wide, and vary from fourteen feet to nine feet lift. The capabilities of the canal admit of vessels one hundred and forty-two feet long, twenty-six feet beam, and ten feet draft. There is also a work connected with this, called the Welland Feeder, extending to Dunville, and the Broad Creek Branch, connecting the last-named feeder with Port Maitland. The Welland Feeder has the same width at top and bottom as the main canal, viz., seventy-one feet at top, and thirty-five feet at bottom, and has eight feet depth; while the Broad Creek Branch has ten feet depth, and in width is eighty-five and forty-five feet respectively at top and bottom. The locks are built of stone, and the whole work, which is under the able control and management of the Hon. H. H. Killaly, Commissioner of Public Works, has received every attention and appliance for facilitating and economizing the transit of the very heavy traffic of which it is the medium.

The Lachine Canal, as before described, was started in the year 1819, upon the limited width described, but in the year 1833, after the fullest attention given to the subject by the Provincial Government, a new system was begun, which proposed to construct works up the line of the St. Lawrence, capable of passing sea-going vessels, and large steamers, suited to the navigation of the upper lakes. And the important works which followed, including the reconstruction of the Lachine Canal, are quite worthy of the age in an engineering point of view.

The Lachine Canal has been widened and deepened, to one hundred and twenty feet width at top, eighty feet at bottom, and ten feet in depth. The terminal points, and the length (which is eight and a half miles) are the same. The locks, which are four in

number, are forty-two feet three inches wide at the lower level, and forty-five feet across at the top-water surface. The maximum lift is thirteen feet, the minimum eight and three-quarters feet. Vessels of one hundred and eighty-five feet length, forty-four feet beam, and nine feet draft, are the limits of capacity.

The navigation from the head of the Lachine Canal upwards passes through Lake St. Louis, and crosses over to the southeast side near the upper end of the lake, to enter the Beauharnois Canal, which is the next work. It connects Lake St. Francis with that of St. Louis, at the foot of the Cascade Rapid, and this canal avoids also the Cedars and Coteau Rapids. The length of the canal is eleven and three-quarters miles. Its width at top-water is the same as that of Lachine. The locks are nine in number, two hundred feet long, forty-five broad at top-water, forty-three and a half feet at the lower water surface. The greatest lift is eleven feet, the least eight feet, and the same class of vessels navigate it as pass the Lachine Canal; it is the only canal which takes the south side of the river,—the mean distance from the American frontier is twenty-five miles.

Passing up stream through Lake St. Francis, we arrive, at a distance of sixty-three miles from Montreal, at the foot of the Cornwall Canal, which is eleven and a half miles long, and surmounts the Long Sault Rapid, which has a total fall of forty-eight feet. The width of the canal is one hundred and fifty feet at top and one hundred feet at bottom, with a depth of ten feet. It is principally formed by reclaiming out of the space originally occupied by the river and its bank, sufficient space for the formation of the cross section described.

It may be as well to remark that the centre of the river from this point onwards, is the dividing line between Canada and the United States, the line of forty-five degrees north latitude striking the River St. Lawrence at St. Regis, a short distance below the lower end of this canal. And it is interesting to observe the small width of the river near this point, as shown on an enlarged plan, and that the narrowest width between United States territory and the Canadian shore is about six hundred feet, measured between the northwestern side of Croiles Island and the canal bank. The locks on this canal are two hundred feet long, fifty-five feet on the top of the walls, and fifty-three and a half feet at the lower level.

The Williamsburg Canal, consisting of four short canals, the last of these so-called St. Lawrence Canals, commences at eighty-nine and a half miles above Montreal, and was constructed to avoid the Farren's Point, Rapid Plat, Point Iroquois, and Galops Rapids, which have a total fall of twenty-nine and a half feet. With the construction of these canals was completed, in 1847, the last link of this great inland system. Their aggregate length is nine and three-quarters miles; their cross section is ninety feet top, fifty feet bottom, and ten feet deep. There are six locks two hundred feet long, forty-five feet wide

at top—forty-three and a half feet at low water. The lift of these locks is eleven and a half feet maximum, three and a half feet minimum.

All these St. Lawrence Canals admit of vessels having an extreme length of one hundred and eighty-five feet, forty-four feet beam, and nine feet draft; but the Cornwall Canal would admit of the passage of vessels with fifty-three feet beam.

The traffic on this part of the river consists of through passenger traffic, which usually assumes some importance about the first week of July, and continues until about the middle of September. The vessels engaged in this traffic are lake-going steamers, which run in connection, more or less, with some of the railways on both sides of the lake, and either in close connection, or in violent competition, with the railways for the through traffic in passengers, which it may be here stated, in the course of the summer can be barely remunerative to either system of transit. The steamers have, usually, side wheels; are very lightly built, having a draft not exceeding six feet; and they perform the distance from Toronto to Kingston, about one hundred and seventy miles (usually by night), in fourteen hours; and from Kingston to Montreal, shooting all the Rapids, in about thirteen hours, the distance being one hundred and seventy-five miles.

This route, which is a highly popular one in the country, and taken by all the strangers who visit, is very attractive through a certain degree of hazard and interest which is attached to the "shooting of the Rapids." This matter has been so frequently described, that it will be unnecessary to offer further comment than will be suggested to any practical mind, and it is believed that few, after seriously thinking over the subject, would venture to recommend the passage of a vessel two hundred feet long, of the flimsiest construction, down a rapid tortuous channel, frequently much less than two hundred feet wide, filled with rocks and boulders of enormous size, and with currents, eddies, and slackwater, as embarrassing as it is possible to conceive of in any navigation.

The traffic of the kind mentioned has been only estimated; exact statistics cannot be obtained; but until within the last three years, the boats were constantly crowded with passengers for three or four months in the year.

It need scarcely be added that the boats return to the point from whence they came by the canals, upper river, and lake, and that they depend for their subsistence chiefly upon the western bound freight in merchandise from Montreal, the chief city of commerce in Canada. The most extensive and important business is carried on by screw propellers, as well as by lake and river schooners, scows and barges. Towing is performed for the most part by steamers.

The water communication between Montreal and the State of New York is carried on by rather an indirect line of navigation, down the River St. Lawrence to the embouchure of the Richelieu, forty-five miles below Montreal, and about one hundred and thirty-five

miles above Quebec. At Sorel, the direction of the route is a little to the west of south. The river has an average rate of about a mile and a half per hour, and in low stages of the river it occasionally runs at the rate of four miles an hour in certain localities; besides which, at St. Ours, there is a decided rapid, having a fall of five feet, where a lock and dam have been introduced, the dimensions of which admit of vessels one hundred and eighty-five feet long, and forty-four feet wide, with a draft of seven feet, and at Chambly another rapid exists, amounting to a seventy-four foot fall, extending through eleven and a half miles of the river. This rapid is overcome by a canal and nine locks, the dimensions of the canal being sixty feet top-water, thirty-six feet at bottom, and eight feet depth; and the locks are one hundred and twenty feet long, twenty-four feet wide at top, and twenty-two and a half feet at low water, and will admit of vessels one hundred and ten feet long, twenty-two feet wide, and seven feet draft. The navigation, which extends up to Lake Champlain, which is reached at about eighty miles from Sorel, meets with no further obstacle, and is continued free through Lake Champlain to the New York Champlain Canal, at Whitehall, where it has only to overcome a height of fifty-five feet before commencing to fall to the tidewater of the Hudson, at Troy.

IMPROVEMENTS TO THE NAVIGATION OF THE INLAND WATERS OF THE NEWCASTLE DISTRICT.

Above the town of Peterboro, the Otonabeo, for some miles, maintains the character of a fine river, nearly two hundred feet wide, discharging a large supply of water at all seasons, and affording admirable sites for factories requiring large power. The river there spreads out into a number of lakes, which are the recipients of several considerable streams: some of these navigable, and some, it is stated, capable of being made so at a very small cost. The connection with this district is of considerable importance, on account of the large quantity of timber abounding in that section, and the valuable nature of the country for agricultural purposes. Some improvements have been commenced, but no very extensive or permanent works executed. Improvements in the Scugog River have been carried on, and a dredging engine employed for the deepening of shoal places. The value of the several reaches of continuous water communication may be considered as created by these limited works, and daily become more manifest. They extend through a distance not less than one hundred and thirty miles; and when the various improvements proposed have been carried out, a great benefit will be extended to a large district of country.

Among the collateral advantages which have been afforded by the construction of the various canals in Canada, is that afforded by their water power, by means of which the

Provincial Government has been enabled to offer encouragement to manufactures on canal banks; and arrangements were made, in the first instance, for a considerable supply of water for manufacturing purposes, which, in several instances, has been carried to a very great and injurious limit: as, for instance, on the Lachine Canal, the velocity in which has become a serious inconvenience to the traffic; so much so, that a large expenditure has been rendered necessary during the present winter, for the enlargement of the cross section through the rock cutting already mentioned near Lachine.

WHARVES AND CRIBWORK.

Having now described the leading public works which have been undertaken in the Provinces, in connection with the navigation of the St. Lawrence, the description would be incomplete if there was any omission of the numerous wharves which have been established upon the various rivers and lakes extending from the lower St. Lawrence upwards. These wharves, in consequence of the great cost, and the difficulties attending the construction of masonry in such localities, have been for the most part built of what is locally known on the continent of America as "cribwork;" and as the work seems to be almost peculiar to this side the Atlantic, and almost unknown on the other, it may be proper to give a description of the character of the work; and to render this clear, some sketches are appended of cribwork, which may be considered fair examples of the ordinary mode of construction. It will be perceived that this cribwork consists of a heavy grillage, or framework of whole timbers, treenailed and dovetailed into each other. The work is put down in sections, and is built floating in the water, and having been brought into the intended site, it is loaded with stone, which, acting as ballast, settles it into its place. After finally adjusting the cribwork to its proper position, stone is added to give weight and stability to the mass, which may be taken as having a specific gravity as compared with water of one and eight-tenths. This cribwork is found to be much more durable than could have at first been supposed, there being wharves now standing in the tideway at Quebec which are said to have been built upwards of eighty years ago. Many of the wharves built in the rivers of Canada and the United States are in the form of jetties, projecting at right angles to the shore, where they are exposed to very severe pressure from the floating bordage ice. And although there are some instances which could be quoted of cribwork being moved by the ice, it was generally to be traced to the want of stone ballast, which is the chief point to be attended to in the construction of these works.

The timber employed is of all kinds, although pine culls, as they are called (which is a third class timber), is chiefly used, in logs of all sizes, and of all lengths.

The average cost of cribwork at Montreal is $1.75 per cubic yard; at Quebec it has

been done for about $1.10; and in Western Canada, $2.00. In all cases, the work was in deep water; and in the case of Quebec, it varied from twenty-eight to thirty-eight feet in height.

The attention of the writer has been drawn to one of the effects of ice, which has not yet been mentioned, and that consisting in the expansion of large unbroken fields of ice, and which has produced the most serious injury to public works.

The line of the Cobourg and Peterboro' Railroad crosses over Rice Lake about ten miles north of Lake Ontario, by a bridge of nearly three miles in length. The lake is about eighteen miles in length, and obtains its maximum width at the point of crossing, and is about twelve feet deep. Early in the season, this lake becomes covered with ice, which occasionally increases to a thickness of two feet.

The bridge or viaduct, for about five-eighths of its length, consists of a series of short spans, of from twenty-five to thirty-five feet clearance, each resting upon blocks of cribwork, about fifteen feet square. The remainder consists of larger spans, some of them extending to even seventy feet opening.

The effect of the expansion of ice has here been felt, and for a few years after its construction the most serious injury was done to the structure. The cribwork in many cases was turned on one side, the whole line moved out of range, and the railway itself was rendered almost impassable.

To obviate, or rather to mitigate this mischief, the engineer ploughed a groove through the ice, on each side of the bridge: the result of which was, that in thus finding the line of least resistance, the ice was broken up, and the pressure greatly reduced. The mischief, however, could not be wholly repaired, and the company has been engaged for the last four years in filling up the lake along the line, thus forming an embankment of earth.

Cribwork is most extensively employed on all the canals, wharves, railways, and other structures of the country.

TABULAR STATEMENT

OF THE LEADING PARTICULARS OF THE PRINCIPAL LAKES REPORTED ON.

NAME.	DISTRICT.	GEOLOGICAL POSITION.	HEIGHT ABOVE SEA.	AREA. Sq. Miles.	DIRECTION OF DRAINAGE.	AUTHORITY FOR PARTICULARS.
Superior,	Canada and United States.	Laurentian, Huronian, and Lower Silurian.	601	31,420	Southwards into Lake Huron.	Logan, Bayfield, Shanly.
Michigan,	Michigan, Illinois, and Wisconsin.	Lower, Middle and Upper Silurian, and Devonian.	575	25,590	Eastward through Straits of Mackinaw to L. Huron.	U. S. Top. Engineers, Bayfield, Houghton, Logan.
Huron,	Canada and Michigan.	. . . .	575	23,780	Southwards by River and Lake St. Clair and Detroit River to Lake Erie.	U. S. Topog. Engineers, Bayfield, Logan, Shanly, Tully, Houghton.
St. Clair,	Canada and Michigan.	Upper Silurian and Devonian.	570	. . .	Intermediate.	. . . .
Erie,	Canada, Michigan, Ohio, Pennsylv'a, New York.	Upper Silurian.	565	10,030	Southeastwards via Niagara River into L. Ontario.	Bayfield, U. S. Top. Engineers, Logan, Hall.
Ontario,	Canada and New York.	Lower Silurian.	234	7330	Northeastwards into River St. Lawrence.	Bayfield, Logan, Shanly, Canadian Bd. Works.
Lakes U. S., Adirondack Mountains, Moose River, Middle Branch. — No. 8,	State of New York, Northern part.	Stated to be in the Potsdam sandstone and Laurentian gneiss, with limestones.	1776	309	By Moose & Black Rivers into Ontario at Sackett's Harbor, and artificially through the Erie Canal to the Mohawk River and Hudson.	Surveyors and Engineers of the New York State Canals.
" 7,			1762	609		
" 6,			1760	53		
" 5,			1691	9		
" 4,			1687	1979		
" 3,			1684	166		
" 2,			1684	175		
" 1,			1684	403		
Forks with South Branch,			1487	. . .		
Memphramagogh,	Eastern Townships.	Lower Silurian and Quebec group.	756	37	By Magog River into St Francis, at Sherbrook.	. . . .
Aylmer,	. . . .	. . . .	795	9	St. Francis.	Geological Survey.
St. Francis,	. . . .	. . . .	890	12	St. Francis River to St. Lawrence at L. St. Peter.	. . . .
Megantic,	Eastern Townships.	Qy. Quebec group.	. . .	. . .	Via Chaudiere R. to St. Lawrence, near Quebec. (Not in drainage area of St. Lawrence.	. . . .
Temisconata,	Lower Canada.	Qy. Quebec group and Lower Silurian.	467	24	Discharge by the Madawaska into St. John at Lit. Falls	. . . .

NAME.	DISTRICT.	GEOLOGICAL POSITION.	HEIGHT ABOVE SEA.	AREA. Sq. Miles.	DIRECTION OF DRAINAGE.	AUTHORITY FOR PARTICULARS.
Lake Huron,	Northwestern district of Canada.	For the most part in the Laurentian and Lowest Silurian.	578	. . .	Draining into Lake Huron.	Surveys of Canada.
Island Lake,			677	. . .		
Wahwaskesh,			714.81	. . .		
Maple,			789	. . .		
Aumick,			898	. . .		
Shesheep,			918	. . .		
Doe,			953	. . .		
Burnt,	All these are in the western side of the watershed in the district lying north of Ontario, south of the French River, and east of the Lake Simcoe drainage.	Chiefly in the Lower Silurian and Laurentian.	1405	. . .	Drain into Lake Huron, within Georgian Bay.	Geological Surveys of Canada.
Canoe,			1384.85	. . .		
Ox Tongue,			1253	. . .		
Lake of Bays,			1109	. . .		
Peninoula,			1007	. . .		
Fairy's,			1001	. . .		
Mary's,			993	. . .		
Muskoka,			790	. . .		
Lake Huron, quoted,			578	. . .		
Confluence of Pettawawee with Ottawa at L'Allumette,	Western Canada, occupying the country now chiefly available for the production of the lumber for Canadian exports.	These lakes are for the most part in Drift or in the oldest Silurian rocks and Laurentian formation.	437	. . .	All these drain into the Ottawa, above Lac des Chats.	Geological Surveys of Canada, under direction of Sir W. E. Logan and assistants.
Traverse,			721	. . .		
Trout,			929.5	. . .		
Cedar,			1050	. . .		
Catfish,			1290	. . .		
Burnt Lake and Red Pine,			1320	. . .		
White Trout,			1336	. . .		
Otter Slide Lake, headwaters of Pettawawee,			1405.85	. . .		

NAME.	DISTRICT.	GEOLOGICAL POSITION.	HEIGHT ABOVE SEA.	AREA. Sq. Miles.	DIRECTION OF DRAINAGE.	AUTHORITY FOR PARTICULARS.
Rideau,	Upper Canada.	Lower Silurian and Laurentian.	400	. . .	Via Rideau River into Ottawa, at Bytown.	Canadian Surveys.
Simcoe,	Upper Canada.	Lower and Middle Silurian.	. . .	. . .	. . . .	. . . .
Lac des Chats,	Upper Canada.	Laurentian and Lower Silurian.	410	. . .	. . . .	. . . .
Balsam,	Upper Canada.	Middle and Lower Silurian and Laurentian and Drift.	820	. . .	Via Otonabee and Trent to Ontario.	. . . .
Cameron,	Upper Canada.		815	. . .		
Sturgeon,	Upper Canada.		793	. . .		
Pigeon,	Upper Canada.		788	. . .		
Salmon Trout,	Upper Canada.	. . . .	758	. . .	Via Mattawan to the Ottawa.	. . . .
Rice,	Upper Canada.	Middle Silurian and Drift.	596	. . .	Via Trent to Ontario.	Shanly and others.
Belmont,	. . . .	. . . .	599	. . .	. . . .	. . . .
Scugog,	. . . .	. . . .	797	. . .	. . . .	. . . .
St. Francis,	Lower Canada.	Lower Silurian.	. . .	. . .	St. Lawrence River.	Bayfield, Public Works' Office.
St. Louis,	Lower Canada.	. . . .	57	. . .	St. Lawrence River.	. . . .
St. Peter,	. . . .	Lower Silurian.	. . .	. . .	St. Lawrence River.	. . . .
Lake Champlain,	Northern New York and Western Vermont.	Lower Silurian and Potsdam sandstone.	95¾	. . .	By Richelieu and Chambly to St. Lawrence.	U. S. Engineers.
Lake George,	Northern New York.	Low'r Silurian, Potsdam sandstone & Laurentian.	325	. . .	Via Ticonderoga Falls into Lake Champlain.	U. S. Engineers.
St. John,	Saguenay.	Laurentian.	300	360	Saguenay River.	Geol. Survey of Canada.
Grand Lac,	Northwest Canada.	Laurentian and Lower Silurian.	700?	560	. . . .	. . . .
Temiscamang,	Northwest Canada.		126	612	Into Nipissing.	Shanly.
Keepawa,	Northwest Canada.		760	92	. . . .	Logan.
Temagaming,	Northwest Canada.	Laurentian.	800	330	Via Nipissing into French River.	Shanly, Murray.
Nipissing,	Northwest Canada.	Laurentian and Silurian.	639	294	Via French River to Lake Huron.	Logan, Shanly.

AGGREGATE OF LOSSES AND DISASTERS ON THE LAKES AND ST. LAWRENCE,

IN STEAMERS AND SAILING VESSELS, INCLUDING THE LOSS AND DAMAGE OF CARGO, FOR THE YEARS 1848 TO 1855, BOTH INCLUSIVE (BEING 8 YEARS).

Manner of Loss.	Steamers.		Propellers.		Barques.		Brigs.		Schooners.		Scows.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Wrecked and Sunk, . .	25	$914,500	19	$903,000	15	$231,500	31	$345,600	182	$1,100,226	7	$12,600
Stranded, ...	52	305,150	35	98,050	14	18,200	82	118,500	377	515,370	11	6,850
Fire, ...	19	492,600	8	222,800					10	47,300		
Damaged, ...	108	385,500	92	361,150	35	87,900	160	222,375	444	644,334	29	15,975
Jettison, ...	4	39,500	19	83,500	3	9,000	9	28,500	46	80,280	2	600
Collision, ...	67	286,000	54	747,440	9	65,700	43	152,950	102	270,300	2	2,300
Sunk and Raised, . . .			1	100,000								
Derrick, ...		20,000										
Flood, ...										25,000		
	275	$2,443,250	228	$2,515,940	76	$412,300	325	$867,925	1161	$2,682,810	51	$38,325

Total	No.	Value.
Steam disasters,	503	$4,959,190

Total	No.	Value.
Sailing vessel disasters, . . .	1613	$4,001,360.

AGGREGATE OF LOSSES AND DISASTERS ON THE LAKES AND ST. LAWRENCE,

IN STEAMERS AND SAILING VESSELS, INCLUDING THE LOSS AND DAMAGE OF CARGO, FOR THE YEARS 1856 TO 1861, BOTH INCLUSIVE (BEING 6 YEARS).

Manner of Loss.	Steamers.		Propellers.		Barques.		Brigs.		Schooners.		Scows.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Wrecked and Sunk, . .	27	$362,650	30	$972,760	15	$154,650	22	$145,850	179	$1,392,048	54	$193,650
Stranded, ...	39	118,455	83	317,770	39	215,343	76	211,050	503	1,336,644	47	48,023
Fire, ...	17	435,000	24	370,600			1	450	4	9,550	1	1,200
Damaged, ...	97	175,675	151	165,740	79	98,830	75	50,485	551	409,419	33	18,000
Jettison, ...	5	16,300	13	67,755	3	5,764	8	17,000	68	72,584	4	360
Collision, ...	41	149,210	58	174,325	29	21,085	37	83,950	235	459,546	12	8,462
	226	$1,257,290	359	$2,068,950	165	$495,672	219	$508,785	1540	$3,679,791	151	$269,695

Total	No.	Value.
Steam disasters,	585	$3,326,240

Total	No.	Value.
Sailing vessel disasters, . . .	2075	$4,953,943.

DAILY MEANS of observed Temperatures at two adjacent stations,—Victoria Bridge and Point St. Charles, Montreal, Canada,—at the hours of 9 A.M., Noon, 3 P.M., and 6 P.M.; and also Temperature of the water of the River St. Lawrence, taken daily, at noon.

1861. JANUARY.	Temp. of Water.	THERMOMETER. 9 A.M.	Noon.	3 P.M.	6 P.M.	Daily Mean.	1861. FEBRUARY.	Temp. of Water.	THERMOMETER. 9 A.M.	Noon.	3 P.M.	6 P.M.	Daily Mean.
1	31.0	23.5	24.0	26.0	25.0	24.60	1	31	20.0	23.5	26.5	28.0	23.25
2	31.0	31.5	31.5	31.0	23.0	29.25	2	31	18.5	21.0	21.0	21.0	20.35
3	30.5	6.5	9.0	11.0	10.5	9.25	3	31	7.0	9.0	7.0	6.0	7.20
4	31.0	11.5	12.5	12.5	10.5	11.70	4	31	— 9.8	5.0	3.5	3.5	0.50
5	30.0	23.5	26.0	25.0	24.0	24.65	5	30	16.0	24.5	28.0	26.0	23.60
6	30.0	15 5	16.5	15.0	12.5	14.80	6	30	26.0	29.0	29.0	27.0	27.80
7	30.0	8.0	11.0	11.0	10.0	10.00	7	30	— 3.0	— 4.0	— 3.0	— 8.0	— 4.50
8	30.0	9.0	13.5	13.5	12.0	12.00	8	29	—28.5	—21.5	—17.0	—15.5	—20.60
9	31.0	3.0	4.5	4 0	5.5	4.25	9	30	—14.5	— 2.5	4.0	— 2.0	— 3.80
10	30.0	12.5	16.0	20.5	16.5	16.40	10	30	15.5	20.5	26.5	29.5	23.00
11	30.0	—17.5	—13.5	—11.0	—10.5	—13.80	11	30	29.5	40.0	39.5	40.0	37.20
12	31.0	—18.5	— 9.0	— 8.5	— 9.0	—11.20	12	32	40.0	41.0	41.5	40.5	40.80
13	31.0	—14.5	— 6.5	— 2.0	— 4.0	— 6.80	13	31	32.0	31.5	31.0	28 5	30.70
14	31.0	— 6.5	— 2.5	4.0	6.0	0.25	14	31	20.0	26.0	29.5	28.5	25.80
15	31.0	13.5	18.0	21.0	22.0	18.65	15	31	23.0	27.0	31.0	31.0	28.00
16	31.0	23.0	23.0	23.5	21.0	22.65	16	31	23.5	30.0	31.5	29.5	28.60
17	31.0	15.5	16.0	15.5	12.0	14.80	17	31	30.0	30.5	31.0	31.0	30.60
18	31.0	— 1.0	7.0	11.0	10.0	6.80	18	30	30.5	31.4	31.0	29.0	30.50
19	30.0	15.0	16.5	18.5	15.5	16.40	19	30	17.0	26.5	27.5	22.0	23.20
20	30.0	8.0	12.0	13.0	11.5	11.10	20	30	19.5	27.5	31.5	32.5	27.80
21	30.0	9.5	12.0	14.0	14.0	12.40	21	30	27.0	30.0	23.5	20.0	25.20
22	30.0	7.5	10.5	13.0	10.5	10.40	22	30	4.5	8.5	11.5	9.0	8.40
23	30.0	1.5	8.0	13.5	6.5	7.10	23	30	6.5	7.5	7.5	7.5	7.20
24	30.0	— 2.0	1.5	8 5	13.5	5.35	24	30	17.0	13.5	13.5	11.0	13.80
25	30.0	25.5	21.0	21.0	20.5	22.00	25	31	14.5	26.5	31.0	28.5	25.10
26	31.0	22.5	25.5	27.5	24.0	23.65	26	31	35.5	39.0	38.5	37.0	37.50
27	31.0	20.0	28.0	27.5	25.0	25.10	27	31	26.5	38.5	43.5	40.5	37.25
28	31.0	14.5	24.5	25.5	23.5	21.30	28	31	34.5	40.0	43.0	41.0	39.65
29	31.0	24.5	28.0	28.0	27.5	27.00							
30	31.0	19.0	18.5	22.0	21.0	20.10							
31	31.0	12.5	15.5	15.0	15.0	14.50							
Monthly Means,	30.57	10.02	13.5	15.2	13.7	12.90	Monthly Means,	30.5	17.0	22.12	23.0	22.5	21.2

DAILY MEANS of observed Temperatures at two adjacent stations,—Victoria Bridge and Point St. Charles, Montreal, Canada,—at the hours of 9 A.M., Noon, 3 P.M., and 6 P.M.; and also Temperature of the water of the River St. Lawrence, taken daily, at noon.

1861. MARCH.	Temp. of Water.	THERMOMETER. 9 A.M.	Noon.	3 P.M.	6 P.M.	Daily Mean.	1861. APRIL.	Temp. of Water.	THERMOMETER. 9 A.M.	Noon.	3 P.M.	6 P.M.	Daily Mean.
1	31	35.5	40.0	41.0	37.0	38.40	1	31	21.5	28.0	29.0	29.5	27.00
2	31	36.0	39.0	39.0	37.0	37.70	2	31	29.5	35.5	35.0	34.0	33.50
3	31	35.0	37.5	43.0	40.0	38.90	3	31	33.0	39.0	36.0	37.0	36.20
4	31	35.0	37.5	39.5	37.5	37.40	4	31	26.5	37.0	42.5	42.0	37.00
5	31	21.0	22.5	21.0	19.5	21.00	5	31	34.5	41.0	43.5	48.0	41.80
6	31	22.0	26.0	23.5	21.0	23.10	6	32	34.5	39.5	42.0	43.5	40.10
7	31	— 7.5	1.0	6.5	6.0	1.50	7	32	31.0	35.5	40.0	43.0	37.50
8	31	13.0	21.0	26.5	24.0	20.70	8	32	28.0	34.5	38.0	38.0	34.60
9	31	38.5	37.0	34.5	34.0	36.00	9	32	32.5	40.0	43.0	41.5	39.20
10	31	31.5	30.0	26.5	24.0	28.00	10	32	35.5	45.5	52.5	52.5	46.50
11	31	12.0	16.5	19.5	19.0	16.70	11	32	38.5	42.0	45.0	47.5	43.20
12	31	24.0	23.5	25.0	21.5	23.50	12	32	35.0	48.0	46.5	45.5	43.80
13	31	14.0	17.0	21.5	22.0	18.70	13	32	46.0	50.0	50.0	50.5	49.20
14	31	5.5	13.5	17.5	13.5	12.50	14	32	43.5	44.5	45.5	45.5	44.80
15	31	17.0	25.5	29.5	24.0	22.70	15	32	32.0	36.0	38.5	39.0	36.30
16	31	14.0	27.5	31.5	31.0	26 00	16	32	33.5	36.0	37.5	36.0	35.80
17	30	— 0.5	1.5	5.5	6.0	3.00	17	32	30.5	31.0	31.5	30.0	30.80
18	30	— 4.5	3.0	7.5	5.5	2.70	18	33	31.5	36.5	40.0	39.5	36.80
19	30	— 4.0	5.0	12.5	11.5	6.20	19	34	34.0	40.0	42.0	42.0	39.60
20	30	7.5	18.0	23.5	20.5	16.10	20	34	35.5	41.5	46.0	45.5	42.20
21	30	15.0	22.5	26.5	25.5	23.40	21	34	43.5	47.5	50.5	52.0	48.60
22	31	29.0	32.5	36.0	35.5	33.60	22	34	41.5	47.0	45.0	45.0	44.70
23	32	27.5	32.5	38.5	38.0	34.20	23	35	47.0	53.0	54.0	53.0	51.80
24	32	34.5	35.5	35.0	30.0	33.80	24	36	39.5	45.5	43.5	43.0	42.90
25	32	27.0	33.5	34.5	33.5	32.10	25	36	45.0	45.5	48.5	47.0	46.50
26	32	37.0	37.5	35.5	35.0	36.20	26	37	42.5	49.0	53.5	53.5	49.70
27	32	34.5	35.5	35.5	36.5	35.50	27	38	42.0	53.5	45.0	43 5	46.00
28	32	24.5	30.0	32.5	33.0	30.00	28	40	52.0	54.0	50.0	49.0	51.20
29	32	30.5	35.0	39.0	32.0	35.20	29	42	46.5	50.0	56.5	59.0	53.00
30	32	42.0	40.5	36.0	33.5	38.00	30	42	46.0	47.5	46.5	46.0	46.50
31	32	17.5	22.5	27.0	28.0	23.70							
Monthly Means,	31 2	21.0	25.8	28.2	26.3	25.40	Monthly Means,	33.8	37.0	42.5	43.9	44.0	41.7

DAILY MEANS of observed Temperatures at two adjacent stations,—Victoria Bridge and Point St. Charles, Montreal, Canada,—at the hours of 9 A.M., Noon, 3 P.M., and 6 P.M.; and also Temperature of the water of the River St. Lawrence, taken daily, at noon.

1861. MAY.	Temp. of Water.	THERMOMETER. 9 A.M.	Noon.	3 P.M.	6 P.M.	Daily Mean.	1861. JUNE.	Temp. of Water.	THERMOMETER. 9 A.M.	Noon.	3 P.M.	6 P.M.	Daily Mean.
1	42	37.5	40.0	43.0	41.0	40.40	1	56	65.0	73.0	73.5	74.0	71.40
2	42	29.0	36.5	40.5	41.5	36.80	2	55	57.0	65.0	73.5	73.0	67.20
3	42	35.0	42.0	45.5	45.0	41.90	3	56	60.0	66.0	70.5	63.5	65.00
4	42	43.5	51.0	55.5	56.5	51.60	4	56	52.0	58.5	62.5	64.0	59.20
5	42	50.5	60.0	62.5	61.0	58.50	5	56	59.5	66.5	68.5	67.5	65.50
6	42	52.0	51.0	52.5	50.0	51.40	6	56	61.0	63.0	63.5	60.5	62.00
7	43	52.5	53.0	56.0	55.0	54.10	7	58	60.5	65.5	70.0	68.5	66.10
8	44	51.5	54.0	54.0	52.0	52.80	8	58	68.0	72.5	79.0	80.5	75.00
9	46	48.5	55.0	57.0	56.0	54.20	9	60	64.5	76.0	84.5	87.5	78.30
10	47	52.5	59.0	63.0	60.0	58.60	10	63	76.0	87.0	91.0	87.5	85.40
11	48	53.5	64.0	66.0	61.5	61.30	11	65	75.5	85.0	90.5	88.0	84.70
12	49	50.0	56.5	60.5	63.5	57.60	12	66	69.0	78.0	78.5	72.5	74.50
13	50	51.0	58.5	67.0	57.0	58.30	13	64	56.5	60.0	63.5	63.0	60.70
14	49	52.0	53.5	58.0	59.0	55.60	14	60	62.0	69.5	65.5	60.0	64.20
15	50	50.5	54.5	60.0	62.0	56.80	15	60	56.0	55.5	61.0	62.5	58.80
16	50	52.0	54.0	56.0	53.5	54.00	16	62	61.0	65.0	67.0	67.0	65.00
17	50	43.5	48.5	52.0	52.5	49.10	17	60	56.5	63.0	67.5	69.0	63.90
18	50	46.0	48.0	53.0	52.5	49.80	18	62	64.5	71.0	71.0	71.5	69.50
19	50	52.0	59.0	61.5	59.0	57.90	19	63	65.0	73.5	75.5	73.5	71.80
20	51	57.5	59.5	59.0	59.0	58.70	20	63	61.5	66.0	68.0	68.5	66.00
21	52	55.0	60.5	61.0	60.5	59.20	21	62	63.0	64.5	63.0	61.0	62.80
22	52	53.5	62.0	65.5	65.0	61.50	22	62	59.5	69.5	75.0	67.5	67.70
23	52	61.0	69.0	72.5	69.0	67.80	23	64	66.0	69.5	70.5	64.5	67.60
24	52	63.0	67.0	66.0	60.5	64.10	24	63	55.5	63.0	67.0	68.5	63.50
25	53	55.0	67.5	66.5	66.5	63.80	25	64	64.0	72.0	76.0	78.5	72.60
26	54	61.0	67.5	70.5	69.5	67.10	26	65	69.5	73.5	75.0	74.0	73.00
27	54	56.0	56.5	59.5	56.0	57.00	27	66	66.5	71.5	74.5	72.5	71.20
28	53	46.0	55.0	53.5	48.0	50.70	28	66	66.5	70.5	63.5	68.5	67.20
29	52	47.5	55.0	54.5	55.5	53.10	29	66	64.5	73.0	75.0	73.0	71.30
30	53	49.0	61.0	66.5	66.0	60.60	30	66	66.0	76.0	77.0	69.0	72.00
31	56	61.0	71.0	73.5	70.0	68.80							
Monthly Means,	48.8	50.6	56.4	59.1	57.5	55.90	Monthly Means,	61.60	63.0	69.4	72.0	70.6	68.77

DAILY MEANS of observed Temperatures at two adjacent stations,—Victoria Bridge and Point St. Charles, Montreal, Canada,—at the hours of 9 A.M., Noon, 3 P.M., and 6 P.M.; and also Temperature of the water of the River St. Lawrence, taken daily, at noon.

1861. JULY.	Temp. of Water.	THERMOMETER. 9 A.M.	Noon.	3 P.M.	6 P.M.	Daily Mean.	1861. AUGUST.	Temp. of Water.	THERMOMETER. 9 A.M.	Noon.	3 P.M.	6 P.M.	Daily Mean.
1	63	58.5	66.0	67.5	65.5	64.30	1	69	69.5	74.0	78.5	77.0	74.80
2	64	55.0	57.5	58.5	56.5	56.80	2	71	74.0	81.0	82.0	81.0	78.20
3	60	60.0	65.0	71.0	73.0	67.20	3	70	75.5	79.5	81.0	78.5	78.70
4	64	68.0	77.0	80.5	79.5	76.20	4	70	75.0	81.0	80.0	76.0	78.00
5	61	72.5	82.0	86.5	86.5	81.80	5	75	72.0	78.0	80.5	71.0	75.40
6	63	76.5	85.0	87.5	85.0	83.50	6	68	66.0	68.5	68.5	68.0	67.80
7	63	76.0	85.0	88.0	82.5	82.80	7	69	64.0	70.5	74.0	73.5	71.50
8	64	78.5	85.5	90.0	81.5	83.90	8	70	66.0	74.5	74.5	73.0	72.00
9	64	77.5	67.5	74.5	73.5	73.20	9	73	65.0	74.0	78.0	75.5	73.20
10	65	70.0	76.0	69.5	72.0	71.80	10	69	72.5	76.5	76.0	68.5	73.30
11	64	55.5	56.5	60.0	59.5	57.90	11	70	63.0	67.5	71.0	70.0	67.80
12	64	59.0	59.0	61.0	60.5	59.90	12	70	58.5	65.0	70.5	67.5	65.30
13	65	59.0	65.0	68.5	67.5	65.00	13	62	60.5	70.0	70.5	68.0	67.40
14	65	64.5	66.5	70.0	70.5	67.80	14	63	60.0	64.5	70.5	66.0	65.20
15	61	60.0	60.5	62.5	62.0	61.30	15	69	66.0	74.5	76.5	73.0	72.50
16	61	63.0	68.0	71.0	71.5	68.40	16	69	66.0	77.5	77.5	75.5	74.20
17	61	63.5	69.5	70.0	68.0	67.70	17	70	67.5	77.5	77.0	74.0	73.40
18	62	67.0	76.5	78.0	74.0	73.80	18	71	68.5	74.5	77.0	74.0	73.10
19	63	69.0	69.0	75.5	75.0	72.10	19	70	60.0	65.5	69.5	69.0	66.00
20	61	63.0	63.5	69.5	66.0	65.50	20	70	60.0	70.0	74.5	72.0	69.10
21	59	61.5	67.0	70.5	68.5	66.90	21	64	67.5	67.5	69.5	70.5	68.70
22	66	63.5	66.0	64.5	64.5	64.60	22	68	61.5	64.0	68.0	65.0	64.60
23	66	61.0	66.0	69.0	70.5	66.60	23	69	60.0	66.0	70.0	68.5	66.10
24	65	65.0	72.0	76.0	75.5	72.20	24	70	68.5	73.0	76.5	68.5	72.90
25	69	69.0	75.0	78.5	76.5	74.80	25	70	66.5	74.0	76.5	74.0	72.80
26	70	71.0	78.5	79.5	76.5	76.40	26	70	69.0	76.0	75.0	72.0	73.00
27	69	75.0	75.5	77.5	76.0	76.00	27	70	70.5	74.5	73.0	73.0	72.80
28	70	74.0	79.0	81.0	79.0	78.40	28	70	67.5	74.5	77.5	75.5	73.80
29	70	69.5	70.5	68.5	73.5	70.00	29	70	66.0	73.0	76.0	74.5	72.40
30	70	69.5	74.0	75.5	76.5	73.80	30	69	65.0	70.0	65.5	65.5	66.50
31	69	68.0	67.0	68.5	70.5	68.40	31	62	56.0	61.5	62.0	60.5	60.00
Monthly Means,	66.60	66.5	70.7	73.0	72.1	70.50	Monthly Means,	69.0	66.1	72.1	72.6	71.2	70.90

DAILY MEANS of observed Temperatures at two adjacent stations,—Victoria Bridge and Point St. Charles, Montreal, Canada,—at the hours of 9 A.M., Noon, 3 P.M., and 6 P.M.; and also Temperature of the water of the River St. Lawrence, taken daily, at noon.

1861. SEPTEMBER.	Temp. of Water.	THERMOMETER. 9 A.M.	Noon.	3 P.M.	6 P.M.	Daily Mean.	1861. OCTOBER.	Temp. of Water.	THERMOMETER. 9 A.M.	Noon.	3 P.M.	6 P.M.	Daily Mean.
1	63	58.0	63.5	67.5	66.5	63.90	1	56	44.5	51.5	56 5	49.5	50.50
2	64	58.0	65.0	69.0	69.0	65.20	2	56	57.0	64.0	66.5	62.5	62.50
3	65	70.5	75.0	77.0	73.5	74.00	3	56	62.5	64.5	63.5	59.5	62.50
4	66	60.0	65.0	66.0	64.5	63.90	4	55	49.0	51.5	50.0	49.0	49.90
5	66	57.5	64.5	65.5	64.5	63.00	5	54	41.5	44.5	45.5	46.5	44.50
6	66	66.0	70.5	71.0	68.5	69.00	6	52	54.5	58.0	59.5	58.0	57.50
7	66	57.0	64.0	69.0	64.0	63.50	7	52	51.0	53.0	53.0	51.5	52.10
8	66	54.5	59.5	62.0	61.0	59.30	8	53	49.5	50.5	52.5	51.5	51.00
9	62	54.0	59.5	63.0	61.5	59.50	9	53	50.0	58.0	61.5	57.5	56.70
10	62	60.0	67.0	69.5	65.0	65.40	10	53	51.5	57.0	62.5	59.0	57.50
11	62	58.0	58.0	56.5	55.5	57.00	11	52	49.5	51.5	52.0	52.0	51.20
12	61	57.0	63.0	66.0	64.5	62.60	12	52	51.0	52.0	56.0	53.5	54.10
13	61	60.5	70.0	72.5	69.0	68.00	13	51	46.0	51.0	49.5	47.0	48.30
14	61	66.5	72.5	72.0	70.0	71.70	14	52	44.5	52.0	55.0	53.0	50.60
15	60	68.0	72.5	72.0	65.0	69.30	15	51	49.5	54.0	55.5	51.5	52.70
16	62	52.5	57.5	60.5	60.0	57.60	16	51	42.5	53.5	58.0	51.5	51.40
17	63	56.5	63.5	65.0	63.0	62.00	17	51	57.0	59.5	62.0	59.5	59.50
18	64	57.0	67.5	73.5	70.0	67.00	18	51	53.0	53.0	50.0	49.5	52.40
19	64	68.0	74.0	75.0	74.0	72.80	19	50	44.5	49.0	54.5	59.5	51.80
20	62	60.0	61.0	60.0	56.5	59.40	20	50	45.5	50.0	47.5	43.0	46.50
21	60	49.5	49.0	48.0	47.0	48.20	21	50	38.5	43.5	45.5	43.5	42.70
22	56	47.0	49.0	50.5	51.5	49.50	22	49	39.5	53.5	54.5	53.0	50.10
23	54	50.5	55.0	57.0	56.5	54.70	23	49	53.0	55.0	50.5	44.0	50.50
24	60	52.5	57.0	61.0	59.0	57.30	24	43	35.5	36.5	37.0	35.5	36.00
25	60	54.0	64.0	66.5	63.0	61.80	25	42	36.5	43.5	45.0	45.0	42.50
26	61	58.0	66.0	69.0	66.0	64.80	26	42	45.5	51.0	50.0	49.0	49.30
27	54	60.5	60.5	59.5	59.0	59.90	27	42	39.5	42.5	44.0	41.5	41.80
28	54	55.0	55.5	55.5	54.0	55.00	28	45	33.5	38.0	42.0	38.5	37.90
29	53	45.0	50.0	51.0	48.5	48.60	29	45	40.0	46.5	52.0	47.5	46.50
30	56	47.0	50.0	53.0	50.0	50.00	30	45	42.0	45.5	49.0	47.0	45.90
							31	42	44.5	48.0	44.5	41.0	44.20
Monthly Means,	61.10	57.2	62.3	64.1	60.0	61.48	Monthly Means,	48.0	47.5	51.0	52.2	50.1	50.10

DAILY MEANS of observed Temperatures at two adjacent stations,—Victoria Bridge and Point St. Charles, Montreal, Canada,—at the hours of 9 A.M., Noon, 3 P.M. and 6 P.M.; and also Temperature of the water of the River St. Lawrence, taken daily, at noon.

1861. NOVEMBER.	Temp. of Water.	THERMOMETER. 9 A.M.	Noon.	3 P.M.	6 P.M.	Daily Mean.	1861. DECEMBER.	Temp. of Water.	THERMOMETER. 9 A.M.	Noon.	3 P.M.	6 P.M.	Daily Mean.
1	42	38.5	43.5	44.5	42.5	42.20	1	33	27.5	29.0	27.5	27.5	27.8
2	42	34.0	36.5	40.0	37.5	37.00	2	32	22.5	25.0	23.0	22.0	23.10
3	42	43.0	45.5	45.5	44.0	44.40	3	32	12.5	15.5	17.5	17.0	15.7
4	41	44.0	45.5	45.0	43.5	44.50	4	32	10.0	19.0	25.0	24.0	19.6
5	41	42.5	46.5	47.5	48.0	46.20	5	32	31.0	33.0	34.0	34.0	33.0
6	41	40.5	43.5	44.0	44.5	43.10	6	32	27.0	30.5	34.0	34.0	31.5
7	41	41.5	46.0	45.5	42.2	43.70	7	32	39.5	42.5	43.0	41 0	41.5
8	40	35.0	38.0	40.0	37.5	37.60	8	32	43.0	46.5	45.5	45.0	45.0
9	40	37.5	39.0	39.0	38.5	38.50	9	32	37.0	40.0	41.5	39.0	39.3
10	40	31.5	38.5	39.5	38.0	36.80	10	32	37.5	40.0	47.5	47.5	43.1
11	39	41.5	42.0	45.0	40.0	42.30	11	32	33.0	26.5	23.5	20.0	25.8
12	38	37.0	37.5	37.5	36.0	37.00	12	32	20.5	26.0	28.5	27.0	25.5
13	38	31.0	34.0	35.5	35.5	34.40	13	32	32.0	37.0	37.5	36.5	35.7
14	37	33.0	35.5	36.0	33.5	34.50	14	32	33.5	41.5	43.0	40.5	39.4
15	36	30.0	32.0	33.0	31.5	31.60	15	32	20.5	24.0	25.0	26.0	23.9
16	36	31.0	34.0	38.5	39.5	35.80	16	32	34.0	39.5	34.5	35.5	35.9
17	34	34.5	36.0	37.5	36.5	36.20	17	32	17.5	22.5	25.0	23.0	22.4
18	33	32.0	35.0	38.0	36.5	35.40	18	32	36.5	37.0	32.5	35.0	35.4
19	33	29.5	32.0	34.0	31.5	31.70	19	32	21.0	31.0	30.0	29.0	27.7
20	33	28.5	33.5	36.5	32.5	32.70	20	32	18.5	14.0	12.5	8.0	13.2
21	33	28.0	32.5	34.0	33.5	32.00	21	32	—3.5	1.0	7.0	10.0	3.6
22	33	30.0	35.5	37.5	34.5	34.40	22	32	21.5	27.0	27.5	25.5	25.3
23	33	33.0	36.5	35.0	35.5	35.00	23	32	23.0	24.5	23.5	24.0	23.8
24	33	33.5	36.5	36.5	33.0	33.60	24	32	17.5	19.0	16.0	12.0	16.2
25	33	34.5	36.0	35.0	34.0	34.90	25	32	—0.0	6.5	8.5	7.5	5.6
26	33	32.0	34.5	34.5	32.5	33.60	26	32	4.5	9.5	13.0	18.0	11.4
27	33	29.0	30.0	30.0	29.5	29.60	27	33	35.5	34.0	20.0	14.0	25.9
28	33	35.0	34.5	31.5	29.0	33.10	28	31	1.0	6.5	9.5	8.0	6.2
29	33	29.0	32.5	35.5	35.0	33.00	29	31	9.0	13.0	12.5	13.0	11.9
30	33	32.0	33.0	35.0	33.0	33.40	30	31	18.0	21.0	21.0	18.0	19.5
							31	31	16.5	20.5	24.0	23.0	21.0
Monthly Means,	36.60	34.4	37.1	38.2	36.6	36.60	Monthly Means,	31.90	22.1	25.8	26.2	24.9	24 95

ANALYSIS OF THE FOREGOING OBSERVATIONS.

1861.	Monthly Mean of Water at Noon.	Monthly Mean Temperature of Air.				Monthly Mean of Air.
		9 A.M.	Noon.	3 P.M.	6 P.M.	
January, ...	30.50	10.0	13.5	15.2	13.7	12.90
February, ...	30.55	17.0	22.1	23.0	22.5	21.20
March, ...	31.20	21.0	25.8	28.2	26.3	25.40
April, ...	33.80	37.0	42.5	43.9	44.0	41.70
May, ...	48.80	50.6	56.4	59.1	57.5	55.90
June, ...	61.60	63.0	69.4	72.0	70.6	68.77
July, ...	66.60	66.5	70.7	73.0	72.1	70.50
August, ...	69.00	66.1	72.1	72.6	71.2	70.90
September, . . .	61.10	57.2	62.3	64.1	60.0	61.48
October, ...	48.00	47.5	51.0	52.2	50.1	50.10
November, . . .	36.60	34.4	37.1	38.2	36.6	36.60
December, . . .	31.90	22.1	25.8	26.2	24.9	24.95
		9 A.M.	Noon.	3 P.M.	6 P.M.	
Yearly Means,	45.80	40.96	45.72	47.30	45.80	45.03

MEAN TEMPERATURES BETWEEN 9 A.M. AND 6 P.M.

Mean of Air, Nov., Dec., Jan., Feb., March (151 days), ...	24.2	Number of days At and below zero, . . .	16
Maximum, ...	+ 47.5	" " " 32°, . . .	113
Minimum, ...	— 28.5	" " " 24.2°, . .	75
Range, ...	76°		
April, May, October (92 days), ...	49.23	At and below 32°, . . .	8
Maximum, ...	73.5	" " above 49.23°, . .	58
Minimum, ...	21.5	" " " 60°, . . .	19
Range, ...	52°	" " " 70°, . . .	3
June, July, August, September (122 days), .	67.91	At and below 50°, . . .	4
Maximum, ...	91.	" " above 67.91°, . .	86
Minimum, ...	45.5	" " " 80°, . . .	14
Range, ...	45.5°	" " " 90°, . . .	3

Total number of days in the year below 32°, . . 121.
Extreme Range of the year between 9 A.M. and 6 P.M., ... 119.5
" " in any 24 hours, Summer, July 10 and 11, ... 20.5
" " " " " Winter, January 10 and 11, ... 38.0

Extreme Range of Temperature of Water, 46°.
Maximum Temperature, 75°. Minimum Temperature, 29°.
Total number of days at and below 32°, 120.

ARTICLE IX.

NOTES ON A MAP INTENDED TO ILLUSTRATE FIVE TYPES OF EARTH-SURFACE IN THE UNITED STATES, BETWEEN CINCINNATI AND THE ATLANTIC SEABOARD.

BY J. P. LESLEY.

Read May 4th, 1866.

VERY little of the topography of America has been published. No large areas have been mapped in such a manner as to show the features of the surface. The State of Massachusetts was trigonometrically surveyed, under the direction of Mr. Borden, in 1830; but the published map of that State, which represents the slopes by hachure lines, fails to show the laws which governed the erosion of its surface, and is defective in details. The State of Pennsylvania was not triangulated; but its topography was carefully studied from 1837 to 1841, in sections or districts, by members of the Geological Survey, under Prof. H. D. Rogers; and these sketch-maps, more or less detailed, were compiled into one State map,* which exhibited, for the first and only time, the characteristic features of the topography of the eastern side of the American continent. Although twenty-six other States of the Union have instituted geological surveys, none of them, with the exception of New Jersey and California, has attempted any elaborate topography. In each case the demands of science were supposed to be satisfied with the tracing and coloring of the geological outcrops in a rude and general way. It is especially to be regretted that that accomplished and lamented geologist, Mr. Percival, did not realize upon paper his exact and exhaustive examination of the surface-features of Connecticut, the State which he surveyed, for it could have been done at that time by himself, with ease; and when done, it would have thrown a flood of light upon some of the most difficult geological structural problems that we have yet to solve.

It is surprising that no State, except Massachusetts, has ever set on foot a general astronomical and trigonometrical survey of its surface. What little of exact determination of latitude and longitude has been accomplished, we owe to the personal labors of Prof. Bache, at first alone, and afterwards with the co-operation of the Coast Survey, of which he is the chief; and to Colonel Graham, Colonel Emory, and other engineers of the U. S. Army, appointed to determine the national boundary lines and to survey the lakes. The last published report of the Coast Survey (Report of Progress for 1863), will show how

* As I have described in my Coal and its Topography, 1856, Philadelphia. The State map was finished in 1841, but not published until 1858.

very far these efforts have fallen short of any general survey of the United States. In fact, they have made no impression whatever upon its vast central area.

It is a portion of this central area that I desire to characterize by the map which I exhibit this evening. I have drawn it on stone, from a photographic copy of a large wall-map, which I constructed at the instance of Mr. T. E. Blackwell, when Managing Director of the Grand Trunk Railroad in Canada, in 1861. One of the most public-spirited and enlightened men that ever crossed the Atlantic, Mr. Blackwell had been occupying himself and ten or twenty assistant observers, for several years, with the meteorological and commercial statistics of the Lake Country, intending to embody these in a memoir on the Hydrology of the St. Lawrence, partly to gratify his own professional zeal and taste for natural science, but more to enlighten his countrymen on subjects connected with the future prosperity of America, of which he was an enthusiastic prophet. Mr. Blackwell's father had been in a previous generation at the head of the profession of civil engineering as applied to canal construction and waterworks in England; and the son, brought up in the pursuits of the father, and inheriting his abilities, was the acting efficient junior member of the commission of three appointed for devising a new system of drainage for the city of London. His untimely death, after a journey in Egypt, where, although a sad invalid, he filled his note-books with the most telling and instructive geological sketches of that country that it has ever been my good fortune to see, prevented the appearance of his memoir before the Institute of Civil Engineers, for which it had been prepared, and was the means of its being published ultimately in the Transactions of the American Philosophical Society, of which Mr. Blackwell had been elected a member only a year or two before his death.

During the final revision of the materials for this memoir, I spent two months, as his guest in Montreal, furnishing him with geological data to exemplify the subject; and our discussions led us to design a second memoir, on the Iron Resources of the United States, to be illustrated by a map, showing not only the positions of the American Iron Works, but also the belts—the geological belts—of ore-bearing formations, upon which their existence depended. This afforded me an opportunity to realize an old and favorite design. Accordingly, I compiled a map of the United States, fifteen feet square, giving my own interpretations of the published topography of every State which exhibited marked features of relief,—basing these interpretations, first, upon the authentic topography of the State of Pennsylvania; secondly, upon my own topographical notes in other States; thirdly, on numerous local and county maps; fourthly, on the better marked portions of the State maps; and lastly, on the colored geological maps of the several States, or parts of States, already published.

The result was very striking. Familiar as I have been for years with the topography

of every part of the United States, and of Canada, east of the Mississippi River, I was surprised at the beauty of the whole representation now for the first time made to the eye. The correlation of parts was very fine, in a geological sense. The plateau of the coal, commencing in Alabama and cut off square by the Hudson, contrasted strongly with the essentially unbroken run of the Quebec Group and Laurentian System, from Georgia to the extreme east end of Canada; while the open valley of the Lower Silurians, everywhere keeping the two systems apart, was most remarkable. The sweep of the Lower Devonian and Upper Silurian escarpments around the end of the Catskill, with their long straight lines through New York and their curve through Western Canada, was likewise beautiful. But the charm of the map lay in its unmistakable utterances respecting different topographical types of earth-surface or strongly contrasted systems of erosion, lying in masses, side by side, or running for long distances in parallel belts.

Thus, for instance, the eye takes in at a glance the whole Blue Ridge, Highland, and Green Mountain belt, full of short sharp ridges, in parallel order, but in echelon arrangement, with irregular summit lines, rising into knobs and peaks from 3000 to near 7000 feet above the sea.

Behind it runs the belt of the Appalachians, composed of interminably long and narrow barrow-mountains, with level summits, seldom 1000 feet in height, looped and gophered in an intricate and artificial style, with lens-shaped coves in the northern part; and on the other hand, in the Southern States, terminating in pairs of perfectly straight ridges, cut off short by faults.

Behind these, again, lies the Great Cumberland-Alleghany-Catskill Plateau, with its horizontal geology and its quaquaversal, arborescent drainage-system, boldly contrasting with the Appalachian topography in front of it, and settling the questions of mode and agency in favor of slow aërial denudation.

Still further west, the low finger-shaped bounding ridges and central plains of the Blue Grass country of Kentucky and Ohio shows another but allied type.

And in the east, the wide belt of low sand-hills, southeast of the Blue Ridge, and the immense cretaceous and tertiary flats of the tidewater country, crenulated with bays and covered with dismal swamps, presents a fifth, differing from all the rest.

This map is now in England. But before it left this country, Mr. Bache obtained permission to have it photographed in sections, in the office of the Coast Survey. And it is one of these sections that I have redrawn on stone and offer as a first specimen of what we have a right to expect when the United States, at peace once more among themselves, and free from the curse of slavery, thank God, shall take up in earnest the work of studying and expressing to the eye the character of the countries which they possess in common. During the Rebellion, however, these topographical section-maps were of a more

pressing interest, for they showed to the Government at Washington what a herculean task it would be to operate with large armies upon the Central Valley of Virginia and East Tennessee, from the Ohio as a base. A glance at this map will explain the long continuance of the Rebellion,—the shifting fortunes of the fight,—the repeated losses of the national arms in Western Virginia,—the necessity for that favorite project of Mr. Lincoln's, a railroad from Louisville to Knoxville, which he was induced to abandon only by the threats of Kentucky,—the peculiarly anti-secession posture of North Carolina, the State of the Smoky Mountains,—and some other points of the history of the last four years,—better than the most elaborate written descriptions alone could do it.

I should be glad to offer the whole map to the Society for publication; but it would not bear reduction to a scale small enough for these Transactions, without losing many of its most interesting features. I have been content, therefore, to select an area which would show the above five specified kinds of topography, and at the same time some of the variations to which two of them are subject, viz.: 1. The broadening of the Blue Ridge belt near its southern end, and its double structure as it runs north into Pennsylvania; and 2. The difference between the looped structure of the Appalachians, about Winchester, and their duplicated straight outcrops, cut off by oblique faults, in the neighborhood of Knoxville.

I have selected this area for other reasons also: the principal one being a hope that it may pique the scientific zeal of some of our younger geologists to study this almost untrodden ground. There are not more than one or two reliable topographical maps of all the area exhibited here, and these are very local. It is a grand field for study, and will bear splendid delineation.

But there is one remarkable feature of this particular area, which holds in reserve, as I believe, the future explanation of one of the largest of our American structural problems—the cause of the rectangular opposition of the southwest- and northeast-outcrop and fault system of the Appalachians to the southeast- and northwest-outcrop and fault system of the lower Ohio, upper Mississippi and lower Missouri region. In the centre of the map it will be seen, that the New River (or Kanawha) heads not, like all the other affluents of the Ohio, on the inside edge or at the brow of the great backbone-escarpment of the Alleghanies, but starts from the recesses of the Blue Ridge, and among the heads of the Atlantic seaboard rivers; that it penetrates the Appalachian belt; and that it finally enters and passes through the Cumberland or Alleghany Plateau, to the Ohio River, by which, in fact, it is continued, almost in the same straight line, to Cincinnati. Now I have no doubt, that with this strangely exceptional thorough-cut, is dynamically connected the 350 fathom fault, which runs parallel to and just north of the New River, and the south side of which carries up the floor of the great Silurian Valley almost to the height of

the surrounding mountains. I must connect with the same feature of surface-topography that whole system of faults (southeast and northwest) to which the asphalt vein of Hughes River and the upthrow of Marietta belong, as well as the northeast- and southwest-cleavage of Western Pennsylvania, the southeast and northwest waves of East Kentucky, the southeast- and northwest-faults which cross the Ohio at Henderson, and the Mississippi in the Burlington region, and the long low island of Huronian and Laurentian rocks, discovered by James Hall, on the Minnesota River, in 1865.

In fact, we see in all this the evidence of a strain or warp given to the earth-crust by some force which has apparently carried down the Azoic and Palæozoic continent under water, toward the south and southeast, permitting the Cretaceous and Tertiary deposits to surround and overlap them in all the Gulf States. It is this warped strain that has snapped our northern anticlinals, and substituted for them downthrow-faults in Southern Virginia and Eastern Tennessee,—the downthrow being usually to the east of the fault, and amounting, in many cases, to the whole vertical distance from the Red Shale of XI (Subcarboniferous) down to the Limestone of II (Lower Silurian).

It is a pity we have none of the minute work yet published, which has been done here and there along the borders of the great coal area, for it would help greatly to explain the true nature of the erosive agency which has relieved an expanse of continent, amounting to one or two hundred thousand square miles (its original limits are unknown), from a superincumbent weight of Coal Measures at least two thousand and perhaps, if capped with Permian measures, five thousand feet in height. It is evident from the map, that the whole of this wastage (with the exception of a small section in the north, drained by the Susquehanna and Delaware Rivers southeastwardly, and by the Genesee and Schoharie Rivers northwardly), has passed off into the Valley of the Mississippi; and thus we can account for a certain due proportion of the Cretaceous and Tertiary deposits of the Southwest. But as these were also products in some measure of an ancient system of short rivers which ravined the eastern slope of the Rocky Mountains along a face of, say, two thousand miles,—and probably also of another, similar, but opposite and shorter system of more important rivers flowing from the Laurentian mountains of Canada westwardly into the same Cretaceous sea,—we must not assign rashly too high a value to the subsidy of deposit paid in by the coal area of the Eastern United States.

We see also that the Cretaceous and Tertiary deposits of the Atlantic coast must have had another origin. And yet this other origin could not be wholly different from the first. For, as the map will show at a glance, the whole Devonio-Silurian (Appalachian) belt, in front of the edge of the arborescently and westwardly drained area of the present Coal Measures, has suffered a still more considerable loss of superincumbent material, the whole of which loss must be represented by the semi-continental area of the flat Cre-

tacio-tertiary tidewater country, through which the rivers, which at first produced it, are still flowing, and extending themselves, as they push forward their deltas, along the present seaboard. Now, from this Appalachian belt, not from two to five thousand feet of rocks, as in the case of the Coal Measures, but from twenty to thirty thousand feet of superincumbent Upper Silurian, Devonian and Carboniferous measures have been swept away, leaving the present floors of Lower Silurian rocks, which constitute the Great Valley (of Winchester, Wythe, and Knoxville), and the other secluded anticlinal valleys behind it. We seem to be restricted by these facts to the conclusion, that the erosion of this Appalachian belt of upturned vertical or steep-dipping Devonian and Silurian outcrops has furnished actually twice or thrice as great a mass of Cretaceous and Tertiary detritus for the Atlantic waters as the Coal Measure areas of the Alleghany-Cumberland plateau has been able to furnish to the great central estuary uniting the Polar Ocean with the Gulf of Mexico in Cretaceous and Tertiary times. What became of all the subsequent wastage which passed down the rivers during Middle Secondary times,—times during which so much of the present Pacific side of the continent was formed:—how far it extends beneath the Atlantic:—how much of it went to form the Central American deposits:—how early began the Gulf Stream to sweep the western wastage round through Southern Georgia and the Carolinas, northeastward, toward New England and Ireland, as it continues doing to-day:—and how much weight we must assign to the third element—the cotemporaneous erosion of the great Azoic (Blue Ridge, South Mountain, Highland) belt, which has always formed a barrier between the disturbed inner Appalachian belt of upturned Palæozoic rocks and the outer floor of gold-bearing Quebec Group (Primodial—Potsdam S. S.) rocks, upon which the Middle Secondary and Cretaceous deposits were thrown down:—are among the questions to be solved by another generation of geologists.

But this much I feel sure of, that the old cataclysmic doctrines cannot be upheld in the light of our present geological knowledge. Erosion by wind and rain, sunshine and frost, slow chemical solution, and spring and fall freshets, has done the whole work. I have long taught that it could not have been accomplished under water level by oceanic currents, because the ocean is a maker and not a destroyer. But I must now abandon wholly the idea to which I have clung, with a slowly relaxing grasp, so many years, that a complete erosion theory demanded some such forces as would have been supplied by the extra efficiency of an ocean translated across the upheaved surface through the air. At the same time, the above considerations make me all the less willing to admit the ice-cake theory of erosion as even approximately true. For if aerial erosion has been going on uninterruptedly ever since the uprise of the Coal Measure continent, how little of the whole effect can have remained over to be still produced at the time when the Glacial epoch set in and the supposed ice-cake began to take the work in hand. The battle has

raged all day; the ground is strewn with the dead; nothing but the rear guard of the beaten army is to be seen; the victors are about to bivouac on the field; now the king's jester rushes forward, waving his sword, and shouting, "Follow me, to victory or death!" We have only to turn our eyes from the dentritic erosion of the Alleghany coal-area, as represented imperfectly upon our map, to contemplate the outspread of Cretaceous and Tertiary country between the Blue Ridge and the sea, to place a proper estimate on the availability of the supposed ice-cake of the glacial era, for sculpturing such continental areas as that of the Coal, reaching from the 43° or 45° down to the 33° or 32½° of latitude, especially remembering how the sculpturing was nearly finished before the glacier was born.

The erosion of the wonderful Green River ravines, in the Colorado country, to a depth of five thousand feet, is not more evidently the product of ordinary meteorological causes than is the erosion of any given segment of the Appalachian or Alleghany districts exhibited upon the map. But the Coal Measure areas show the truth most plainly. The ravines which debouche upon the Blue Grass area south of the Ohio, along a line extending from Portsmouth in Ohio, to Somerset near the Tennessee line, all have vertical walls of Conglomerate (Millstone grit), supporting a sadly wasted Coal Measure country above, and overhanging steep slopes of Subcarboniferous shales and limestone below. This limestone, horizontally outcropping on each side of every ravine, and with a delicate dip towards the southeast, is full of caverns; while sink-holes in the Coal Measure country above show that their ramifications extend beneath the whole surface. Fine springs issue from them; robbers have always haunted them; and guerilla bands, during the late Rebellion, made many of them famous for deeds of blood.

Towards their outlets these ravines are gradually cut down through the Devonian sands and shales into the Silurian limestones next below. An opportunity is thus afforded for the escape of all the waters concealed within a second system of branching caverns belonging to this formation, far larger than the one above. These lower limestone waters are highly magnesian. The underground erosion, the concealed dilapidation of the Silurian limestones by their disintegrating reactionary chemistry, is extensive beyond conjecture and growing daily. A world of natural catacombs must underlie the many thousands of square miles of surface represented by the northwest quarter of the map.

I believe that this chemical element of erosive energy has been slighted even in discussions the most recent. I ascribe to it nine-tenths of the wastage of the Blue Grass area. I believe that the erosion went on, chiefly underground, along those narrow belts where the lime-rock formations approached the surface at whatever level the surface happened at the time to stand. The caverns grew; their roofs fell in; streams washed the debris continually away. As the surface thus kept falling piecemeal into the cavernous traps everywhere laid for it below, the general level of the area was slowly and insensibly let down

to its present grade above the sea. While falling thus, the opposing outcrops of the upper rocks retired from one another, eastward and westward, and let the Blue Grass area between them widen slowly to its present size. And still the work goes bravely on. The Mammoth Cave is only one of many thousands which border the central anticlinal Blue Grass country, crossed by the Ohio River.

The same method of erosion, by caverns and sink-holes, is observable in all the Appalachian limestone valleys east of the coal area, explaining, I think, the depth of their limestone floors, as compared with the sandstone mountains which environ them.

There can no longer be entertained a doubt of the existence of vast sheets of ice upon the surface of this continent at certain epochs. Even changes of sea-level may be calculated by considering what must have been the amount of water necessarily abstracted from the sea at first for their production, and again restored to it at their destruction. But we surely cannot accord even to the heaviest conceivable ice-cake of the glacial or any other era the honor of eroding our topography. Without referring to such profound abysses as the Valley of the Saginay in Labrador, the Yosemite Valley in California, or the new-found chasm of the Albert Nyanza in Tropical Africa, it is sufficient to look at the map before us to feel the absurdity of the suggestion.

If such an ice-cake ever passed over our mountains, it must have had its southernmost limit somewhere along a line drawn through the middle of Pennsylvania. Otherwise, why has no diluvial scratch or groove ever been put on record from any point south of the Turnpike notch in the summit of the Fourth or Peters Mountain, fifteen miles north of Harrisburg? And why do not genuine erratics exist in Southern Ohio? Outcrops in Virginia could receive and should retain striæ quite as well as outcrops in Pennsylvania, for they are in all respects similar. Ice had no hand in Appalachian erosion. All it has done has been done in the north, and its only action was to polish a surface already made. It has left no other trace of its existence. It had no mountain summits from which to receive moraine matter, and no moraine has been as yet discovered out of New England and Northern New York. The northern outcrop-sides of some of our east and west-running (eight to twelve hundred feet high) Appalachian ridges in Pennsylvania, are as uniformly sheeted with angular blocks, detached by frost and tumbled down by slow wastage of supporting shales, as are the southern outcrop-sides of the rest of them. Ice has had no hand in this, except the ice of winters innumerable, that of 1866 included in the count. These angular-stone facings are no moraines; and the solitary alleged moraine, at the mouth of one of the twig vales of a branch of Pine Creek in Northern Pennsylvania, ought to be well studied before it be accepted as a product of anything else than the freshets which carry destruction periodically down along our river-beds.

It has not been my intention to write a memoir on Erosion, but to show how far-reaching those suggestions are which such a map produces to the eye of the geologist.

ARTICLE X.

ON FUCOIDES IN THE COAL FORMATIONS.*—[With a Plate.]

BY LEO LESQUEREUX.

Read May 18th, 1866.

§1. DISCOVERY OF FUCOIDES IN THE COAL MEASURES OF SCIENTIFIC IMPORTANCE.

The scarcity of Fucoidal remains in the strata of the true Coal Measures is so remarkable that it is questionable whether any species of true marine Algæ has heretofore been described from these formations. Up to 1836 one specimen of Fucoides only is mentioned in Thompson's Outlines of Mineralogy, Geology, and Mineral Analysis, at the end of a catalogue of fossil plants of the Coal Measures, containing 290 species, under 37 genera.† Since that time, none of the palæontologists who have enumerated or described coal plants, have noticed a single species of Fucoides from the Carboniferous formations, either of Europe or of America, except the doubtful forms which I have noticed in a former paper.‡ Considered in itself, therefore, the discovery of true Fucoidal remains in strata ascertained to belong to the Coal Measures, is a subject of some scientific interest. This fact, moreover, is intimately connected with the question of the distribution of Fucoidal remains in formations of different ages, and of their value and significance for the identification of the strata where they are found. It bears also upon the problem of the economy of marine Algæ in nature: that is, of the amount and worth of the materials which they have brought and still bring to the economizing forces of this omnipotent treasurer. Viewed under these various aspects, the subject may be considered indeed of some scientific importance.

§2. HABITAT OF THE FUCOIDES HERE EXAMINED.

The habitat or the position occupied by the plants described here, is somewhat peculiar. They were found attached or flattened on the lower surface of a thin stratum of limestone, immediately overlaying a bed of coal six to eighteen inches thick. The Fucoides, for they belong evidently to a kind of marine plants, have thus grown, either as a part of the ma-

* In these remarks, the term *Fucoides* is used in its general sense, as representing remains of evidently marine plants, or Algæ, whose relation to living species is obscure or not yet fully ascertained.

† Quoted by J. P. Lesley, Manual of Coal, p. 219.

‡ Silliman's Journal (2), vol. xxxii, p. 194.

terials of which the coal is a compound, or immediately over them. For they appear to derive the black color, which seemingly paints them on the limestone, rather from the coal than from their own substance. When some detached blocks of the limestone have fallen into the creek, and, washed for a time, have been cleared of the coal which adheres to the lower surface, the matter becomes bleached, and the remains of Fucoides appear in slightly depressed and dark distinct outlines. But when the coal, which adheres to the limestone as if it was strongly glued to it, is removed by mechanical force, the stone preserves its black color, and the remains of these plants are scarcely discernible. On the line of contact with the coal and for one or two inches above it, the limestone, whose thickness varies from twelve to eighteen inches, is somewhat shaly, though of a piece, and homogeneous. It is a kind of black band, containing sulphur and iron in large proportions, and essentially composed of broken remains of innumerable marine shells. Though hard, compact, and in banks generally continuous, it breaks into large cuboidal pieces. The Fucoides, which occupy only a few inches of the lower and shaly part of this limestone, are mixed with the remains of shells, and often perforated and lacerated by them.

§ 3. NAME AND DESCRIPTION OF THE PLANTS.

Caulerpites marginatus, spec. nov., is the name of these Fucoidal remains. Their form, however variable,* may be compared to that of a lyre or harp. From a horizontal base, the margins, at first nearly parallel, slightly diverge in ascending, and then unite into a rounded top, as in fig. 2. Or the outer margin, diverging more in ascending from the base, becomes more extended than the other, and is once or twice broadly lobed or only wavy, as in fig. 3. The fronds vary in length from two inches to one foot, are half as broad as long, and surrounded by an apparently fleshy or tubular margin from one-eighth to one-fourth of an inch broad. Strongly arched ribs, apparently produced by alternate inflation and thinning of substance, pass from the inner side of the rim to the other border, filling the whole lamina. These arched lines look somewhat like the forking or dichotomous thickened veins of some *Cyclopteris* of the coal. But they are not true nerves, for they do not regularly branch or connect with each other. They abruptly vary in thickness or change their general direction, even crossing each other in various ways. This last appearance is likely caused by compression of a body somewhat inflated like a bladder. The ribs, thin and narrow at and near the margin of the frond, are enlarged in the middle. They seem to be produced by such a spongy network of anastomosing filaments, as is seen in some of our living Algæ, which serves especially to strengthen the structure of the plants. The base of the fronds, abruptly and nearly horizontally cut, is joined at one of its corners, generally more acute than the other, to a stalk or stipe, per-

* See plate 1.

haps a primary stem (*surculus*), which is either linear, elongated, apparently tubular, connecting the frond with some point of attachment, or a short, inflated, oval, bladdery tubercle, resembling an organ of suspension in water. These stipes vary in thickness from one-fourth to one-half of an inch, are very abundant on the limestone, much more so than the fronds, appearing like flat cylindrical pipes, mostly simple, curved in many ways, and generally somewhat inflated at one end. I have copied fig. 7 of plate 1, as it is seen on the stone. It seems to represent a branching stipe. But this is probably a deceptive appearance, caused by a casual superposition and compression of three different parts of simple stalks.

§4. RELATION OF THESE FUCOIDES TO OTHER SPECIES OF THE PALÆOZOIC AGES.

These Fucoidal remains so remarkably resemble some of those figured by Mr. Vanuxem, in his Geological Report of New York, under the general name of *Fucoides Cauda-galli*, *Fucoides velum*, &c., that their close relation cannot be denied. Specimens of our species, when the rim has been casually destroyed, are exactly like fig. 2, p. 128, of Vanuxem's *Fucoides Cauda-galli*. Indeed, except the border, it would be impossible to point out any character which might serve to specifically distinguish them.

In a re-examination of these fossil plants, the celebrated palæontologist, Prof. James Hall,* considers the circular form of the frond of *Fucoides Cauda-galli* as a result from its development around an ascending spiral axis, the frond expanding more and more in ascending. In consideration of this peculiar mode of growth, the author has grouped the plants of this kind into a new genus, *Spirophyton*, in which he enumerates four species: *S. Cauda-galli*, *S. velum*, both old species of Vanuxem, and *S. typum* and *S. crassum*, two new species.

Though the very clear descriptions and good figures given by Prof. Hall seem indeed to indicate, at least for his new species, the growth of a frond around a spiral axis, it is plain also that we cannot suppose for the plant here above described a similar mode of development. The same can be said, I think, of both the forms represented in Prof. Hall's report, the one p. 80, fig. 2, which the author considers as a distorted portion of a last volution of a spiral of *Spirophyton Cauda-galli;* and the other, p. 81, fig. 3, named *S. velum*. For the first of these fronds has, as it has been remarked, exactly the same general form and appearance as the plant represented fig. 2 of our plate, and the other bears at one of its corners the broken remains of what is rightly called a stem by M. Vanuxem, which indicates a mode of growth similar to that of our *Caulerpites marginatus*. Therefore, these closely related three forms should be forcibly ejected from the genus *Spirophyton*, this name being inapplicable to plants whose growth has been as a plain untorted lamina.

The way of reconciling these discrepancies is, I think, to admit that the fronds of this

* Seventh Annual Report of the Regents of the University of New York, Appendix D, pp. 76 to 84.

group may casually, under peculiar circumstances of habitat, have their laminas or fronds contorted or twisted around their axis, which is here merely lateral. This twisting occurs in a remarkable degree in many species of our living Algæ, especially in those of a hard leathery texture. The most common *Fucus vesiculosus*, for example, can be seen around Boston, on grassy meadows submerged at high water, with its fronds so strongly twisted that its length is reduced by one-half, and that it then looks rather like a whorl of leaves surrounding a central axis than like a long flat linear frond, which it is really. If, therefore, fronds, like the one represented p. 80, fig. 2, of Prof. Hall's report, or plate 1, fig. 2, of ours, whose length attains one foot, were twisted around a lateral axis, here the continuation only of the primary stem, which may force the torsion, the figure resulting from a cross-section of any part of the twisted frond, or from its perpendicular compression, would represent a disk just like that of the new species of *Spirophyton*. And the same twisted leaves, if compressed in different ways and at various angles, would of course produce multiple deformations like those remarked in the polymorphous *Fucoides Caudagalli*. If this supposition is right, and if all the forms under which the Fucoides of this group are seen, may be explained by it, it excludes the necessity of a new genus and prevents the scattering of plants of similar characters into different groups.

§ 5. RELATION OF THESE FUCOIDES TO LIVING ALGÆ.

It is right to remark, nevertheless, that we have now a genus of living Algæ, represented by one known species only, whose growth seems to be somewhat analogous to the spiral development of the *Spirophyton*, as it is described by Prof. Hall. It is the *Thalassiophyllum clathrus*, Post and Rup., growing on the northern shores of the Pacific, in Russian America. According to Mertens, who has described it, the stipe of this plant is very bushy and branching, each branch bearing at its extremity a leaf, which unfolds spirally in such a manner that a spiral border, wound round the stipes, indicates the growth of the frond. This frond presents a large convex bent lamina without nerves, or, to a certain degree, a leaf, of which one-half is wanting, for the stipe may be considered as an eccentric nerve.* Though an analogy of development may, from this description, appear to exist between the fossil and these living Algæ, there is, I think, an evident and great difference. In Spirophyton, as it is described and figured, it is not a kind of border or stalk, which causes by its own twisting the bend of the frond; it is the lamina which unfolds itself in spiral from its point of attachment and expands in ascending. Hence, fronds of this kind can be but simple, while the Northern Algæ of the Pacific are remarkably bushy branching. These, moreover, belong to a class of highly organized Algæ, while in early geological ages and from analogy with what we know of other beings, we can look in the vegetable world for types only of a very simple organization.

* T. H. Harvey's Nereis Boreali Americana, vol. i, p. 97.

This simplicity of structure, with some peculiar characters of the Fucoidal remains under examination, seem to fix their relation with the *Caulerpæ*, a group of Chlorosperm Algæ of our time. "The fronds of these plants consist of prostrate primary stems (*surculi*), rooting from their lower surface and throwing up erect branches or secondary fronds of various shapes. Their substance is horny, membranaceous, destitute of calcareous matter, their structure uncellular, the cell (or frond) continuous, strengthened internally by a spongy network of anastomosing filaments, and filled with a semi-fluid grumous matter."* The primary fronds or stalks of the species of this order are smooth and glossy, a character particularly marked in *Caulerpites marginatus* of ours. For, on the limestone, even when it has not been washed by the water of the creek, these stalks of a dull grayish color are clearly defined, perfectly smooth, even shining or polished. The development of the secondary fronds of the Caulerpæ is multiform in the extreme, as can be expected in a plant which is of the simplest structure and is formed by the continuous development of a single cell, or is, so to say, nothing but a kind of bag of a flexible tissue. In *Caulerpa prolifera*, Lam., the secondary frond expands into a tongue-shaped, flat petioled, leaf-like division, which is itself proliferous from any part of its surface. In other species the secondary fronds are sometimes pinnately branching into elongated bladdery cylindrical appendages, sometimes irregularly divided into ribbon-like branches, without any appearance of order. Even in *Caulerpa clavifera*, Ag., these secondary fronds are more or less densely set all around by scattered club- or top-shaped vesicular branchlets. The only character which renders our fossil plant in some way different from the forms which we are accustomed to find in this group of Algæ, is its eccentrical shape. But it is seen from plate 1, fig. 4, that the secondary frond is not a second frond, implanted on or born from the primary one, but is really a mere continuation by inflation of the stalk. This, expanding like a bladder, is forced upwards, the division of the stalk forming the thickened or smooth border around it. The stalks or surculi, as seen in figs. 5 and 6, are inflated in various ways, and may, even after dilating into laminas, take again their tubular, more simple form, a disposition which is seen also in some species of *Caulerpæ*.

It is in consideration of those natural affinities, that I have placed the new species of Fucoides of the coal in the genus *Caulerpites* of Sternberg; and the same reasons would induce me to admit into it all the related forms described by Prof. Hall under the name of *Spirophyton*, as well as the peculiar *Fucoides Serra* described by Brongniart.† This last, according to the remarks of that celebrated author, was found in the limestone of Transi-

* Nereis Boreali Americana, by T. H. Harvey, vol. iii, p. 12. Most of the remarks concerning the Caulerpæ are taken from this admirable work.

† Vegetaux Fossiles, p. 71, tab. 6, figs. 7 and 8.

tion at Point Levy, near Quebec, Canada. Its likeness to our species is rather in the mode of growth than in the form. It has nevertheless an eccentrical expansion of the secondary frond, from a round, linear, apparently tubular stalk, which is sometimes only a bladdery oval tubercle. The fronds themselves, though narrower, deeply dentate on one side, and without arched ribs, have the same general outline as *Caulerpites marginatus*. Indeed, in comparing the upper part of fig. 7 of Brongniart with fig. 6 of our plate, or fig. 8 of Brongniart with our fig. 2, one can but see that these so nearly allied forms are of a same type, and can but be admitted in the same genus.*

§6. GEOLOGICAL HORIZON OF THE LIMESTONE MARKED WITH REMAINS OF CAULERPITES MARGINATUS.

The new species of *Caulerpites* was found on Slippery Rock Creek, opposite Wurtemberg, Lawrence County, Pennsylvania, at the base of a hill about three hundred and fifty feet high, abruptly cut down by the erosion of the creek. The succession of the strata thus open to view is seen in the following order, ascending:

1st. At the low-water level of the river, a bed of soft, black, easily disaggregated shales, intermixed with small oval pebbles of carbonate of iron. At its upper part, the shales pass into a kind of yellowish ball or clay iron ore, their whole thickness varying from five to eight feet here around.†

2d. They are overlaid by a bed of bituminous, hard splint coal, sometimes shaly, five to twelve inches thick, rarely more, covered by the limestone, with Fucoidal remains, as it has been described above. At Wurtemberg this limestone is one foot thick. In ascending the creek to about five miles above this place, it continues in view at the base of the hills wherever they are cut by erosion. It preserves the same horizon, is marked by the same species of plants, and its greatest thickness is not over eighteen inches.

3d. Over the limestone, fifteen feet of soft, grayish shales, without any trace of remains of fossil plants.

4th. A bed of sandstone, five feet thick, passing sometimes to a hard compound of coarse-grained fire-clay, with leaves and stems of Stigmaria.

5th. Two feet fire-clay.

6th. Three feet hard black limestone, of the same appearance and compound as the limestone of the Fucoides, but without remains of plants.

7th. A succession of thick strata of shales, cut by thin beds of Stigmaria fire-clay and shaly sandstone, with streaks of coal. The shales have an average thickness of one

* Prof. Brongniart (loc. cit.) compares his fossil plant to some species of *Amansiæ*, especially to *Amansia semipinnata*. Prof. Unger, in his Genera and Species, places it in the genus *Sphærococcites* of Sternberg.

† At some other places, on Beaver River for example, these shales attain a thickness of twenty feet, being cut or underlaid by one or two beds of coal, as in Kentucky.

hundred and fifty feet, while the intermediate strata do not have altogether a thickness of twenty-five feet. The shales are generally soft, slightly micaceous, and black-spotted by oxide of iron. They contain in places a quantity of branching cylindrical Fucoides, mostly resembling the small variety of what has been called *Palæophycus tubularis* by Prof. J. Hall.*

8th. These shales are still overlaid by a thick bank of hard, gritty, micaceous sandstone, generally conglomerate at its upper part, and capping the hills here around. Its lower part, somewhat shaly, is also marked by abundant Fucoidal prints. I say *prints*, because these Fucoides in the sandstone are not true remains of plants, but only the moulds left by the decay of marine Algæ, whose place has been filled by a softer whitish sand. Accordingly, the original form of the plants are pretty distinctly printed on the stone. The moulds are generally placed horizontally on the stones, but sometimes penetrate them obliquely or even vertically. These Fucoides are somewhat thicker than those of the shales, varying in thickness from one-half to one inch, either simple, like flexuous pipes, or irregularly forking on one side only, or dividing from a central axis, and sending branches in every direction. They have, as much at least as can be seen from these moulds, the same form and size as the large variety of *Palæophycus tubularis*, Hall, as it is represented figs. 1 and 2, quoted above.

Though the shales of this section are mostly soft, grayish, apparently well fitted for the preservation of remains of coal plants, there is not, in the whole, any trace of ferns or of any of the species of land plants generally and commonly found in the Carboniferous measures. At one place only, just below the mill, one mile above Wurtemberg, the bed of coal at the base of the section is divided into two members by a shaly sandstone, which bears the prints of the bark of *Calamites*, *Lepidodendron*, and *Sigillaria*. The upper division of the coal is here still overlaid by the limestone with *Caulerpites marginatus*.

This distribution of strata strikingly resemble what is seen in some part of the Subcarboniferous measures of Kentucky, Illinois, and Arkansas, where the upper and even the second bed of the Archimedes Limestone are underlaid by shaly sandstone, marked with remains of large coal plants, especially trees and thin strata of coal. In the same way the fossil remains covering the soft shales and printed with the upper Conglomerate Sandstone, are like those remarked in the Chemung, along Oil Creek, or in the Waverly Sandstone of Ohio. They appear indeed identical. Relying then on palæontological evidence, I could but consider the hill opposite Wurtemberg as formed mostly of Chemung measures, and the Conglomerate Sandstone of the top as the equivalent of the Millstone grit. It was only after conferring upon the matter with my friend, Prof. J. P. Lesley, than whom no

* Palæontology of New York, vol. i, p. 7, tab. 2, figs. 1, 2, 4, 5.

geologist is better acquainted with the distribution of the measures in the whole extent of Pennsylvania, that considering the anomaly of the presence of the Chemung in that part of the State, I began a stratigraphical survey of that country, disregarding every kind of palæontological evidence.

Beginning at Homewood Station in Beaver County, the Millstone grit is there exposed along Beaver River with a thickness of one hundred and sixty feet, its base resting on a bed of ball and clay iron ore, soft black shales, with pebbles of carbonate of iron, thin layers of coal, &c. Higher up, at Homewood Furnace, and at the mouth of Coneconessing Creek, the Millstone grit is still one hundred and ten feet thick, and is underlaid by the same kind of shales and ball iron ore. Up the Coneconessing the stream flows between banks of the Millstone grit, which slowly decreases in thickness. At the mouth of Smalley's Run, six miles above, these measures are only sixty feet thick, and the Subcarboniferous strata exposed there show the same nature and distribution as at Homewood Station. The thinning continues at about the same rate to the mouth of Slippery Rock Creek, where banks of hard Conglomerate, forty feet thick, descend to nearly the level of the river. Six to eight feet of Subcarboniferous measures are exposed here at low water. From here, in ascending Slippery Rock Creek, the decrease in the thickness of the Millstone grit becomes more rapid and irregular; these strata changing here and there into shaly sandstone, five to six feet thick, then disappearing entirely, to be seen in place again a little higher up in the creek. The last appearance of the Millstone grit is just below the lower mill at Wurtemberg, where the sandstone, still hard and gritty, is six feet thick, and the black shales and clay iron ore are exposed under it six to eight feet thick; there it definitely loses itself in a thin bed of soft shaly sandstone, wedging into the top of that clay iron ore which in the section is marked as under the bed of coal. From Wurtemberg these strata, preserving the same character and horizon, continue along the creek, without any trace of sandstone, to six miles above, where the Millstone grit reappears in the same manner and at the same horizon as it is seen passing away at Wurtemberg, and rapidly increasing in thickness. At Seceder's Bridge, nine miles above Wurtemberg, it is already one hundred and ten feet thick, underlaid by forty-nine feet of Subcarboniferous measures.

From these observations it follows:

1st. That the whole thickness of the strata marked in the section of the hill opposite Wurtemberg, including the lower bed of coal and the limestone with Fucoidal remains (*Caulerpites marginatus*), belongs to the Carboniferous formations.

2d. That, from Homewood Station to Seceder's Bridge, a distance which, in a straight line, is not more than fifteen miles, there is in the Millstone grit formation a wide, nearly abrupt gap, about five miles broad, where the Carboniferous measures, immediately overlaying the shales of the Subcarboniferous, are mostly marked with remains of marine

plants of the same type, if not of the same kind, as those which we generally consider as characterizing the Chemung group.

§7. GENERAL DISTRIBUTION OF SOME SPECIES OF FUCOIDES IN THE PALÆOZOIC AGES AND THEIR VALUE AS CHARACTERS OF SYNCHRONISM.

The moulds of Fucoidal plants, observed in abundance at the base of the gritty sandstone which caps the hills at and around Wurtemberg, about the height of three hundred feet in the Coal Measures, represent a species apparently identical with, or at least undistinguishable from the large variety of *Palæophycus tubularis*, Hall. The Fucoides in the shales, inferior to this sandstone, resemble the small forms of the same species and *Palæophycus irregularis*, Hall, which Prof. Göppert considers as a mere variety of it. Now, the remains of marine plants of this kind already appear in the Lower Silurian Calciferous sandstone, and may be considered as representing some of the primordial types of the vegetable world. The polymorphous *Fucoides antiquus* of the authors (*Buthopteris antiquata*, *B. gracilis*, *B. palmata*, *B. impudica*, *B. ramosa*, Hall) is common in strata of the Upper Silurian Clinton group; is especially abundant in the Chemung of Pennsylvania and Ohio, and reappears in the Cretaceous formations of Europe. At least *Fucoides Targioni*, Brgt., of this epoch, so well resembles in its multiple varieties the different forms of *F. antiquus*, that it cannot be separated by appreciable characters.* The group of Fucoides, which we have examined in this paper, has representative fossil remains, apparently identical in species, in the whole extent of the Devonian Measures. At least the same form of *Fucoides Cauda-galli* of the Corniferous period is seen in the Chemung or Waverly sandstone of Ohio, and is especially abundant in strata scarcely fifty feet lower than the base of the Millstone grit of Southeast Kentucky. It may be that the fossil remains represent different species, for even *Caulerpites marginatus*, which ascends into the Coal Measures, is, when its border is casually destroyed, undistinguishable from *Fucoides Cauda-galli*.* But we are authorized from these facts and others of the same kind to conclude that most of the marine Algæ, of which remains are found in the Palæozoic strata, have had a wide range of distribution. From this, it is contended, perhaps rightly, that they cannot be considered as reliable guides in the determination of geological horizons.

If this discredit was limited to the remains of marine Algæ only, it would perhaps not be worth considering in any way. But it touches, by inference, every kind of fossil plants, and thus tends to eliminate as useless some palæontological data which are certainly of practical importance. I allude to the remains of land plants, especially the coal plants, some of which may be justly considered as characteristic even of the horizons of the various beds of coal.

* Geological Report of Pennsylvania, p. 848. Göppert, Fossil Flora des Silurischen, p. 434.

We know little indeed of the true forms and nature of fossil Hydrophites. Mere cellular plants as they were, nothing of them has been preserved by fossilization but some moulds or indistinct impressions; hence the impossibility of discovering peculiar forms of organism, which might be used as reliable specific characters. In looking over the innumerable remains of Fucoides, which cover some strata of the Chemung of Pennsylvania or of the Waverly sandstone of Ohio, for example, we perceive at first such differences in the shape of these fossils that their separation into groups appears an easy task. But in time, when these remains are more thoroughly studied, the gaps are filled by so many intermediate forms that the whole fields of this vegetation of old appears like a grass-plot, each blade of which has some peculiar feature, but none marked enough to make it positively distinct. Therefore we are led to admit, either that there are nearly as many species as individuals, or only one species, represented by a great number of closely allied varieties. Of course the impossibility of separating these fossil remains into well-characterized groups renders them unavailable as geological guides.

This difficulty is not met with in the study of the fossil coal plants. For, like the acrogenous vegetables of our time, a class to which they mostly belong, they have woody tissue and vessels as constituents of their stems and foliage, and thus generally preserve their essential forms, in the process of mineralization, at least under certain circumstances. The leaves are not only well defined in outline, but their surface is generally marked by a distinct system of nervation, peculiar to most of the species. Some of these may be followed and studied in the development of leaves, branches, trunks, and even fruits, the trunks being recognizable by peculiar cicatrices on the bark, and the fructifications being sometimes found attached to the plants to which they belong. Hence, if the generic and specific characters of these plants cannot be established on a true scientific basis, they are nevertheless evident enough to allow an identification of the remains found in connection with the beds of coal, and thus to permit a reliable comparison in their distribution, or to fix the peculiar horizon where groups of these plants may belong.

On the other hand, marine plants, like every other kind of vegetable, are apt to modify their shape or to vary according to influences affecting the medium in which they live. In the palæozoic times the temperature of the sea was regulated rather by the heat of the earth than by atmospheric action, and thus was scarcely variable. The same forms of life could therefore be preserved in this medium for a great length of time,—longer indeed in the vegetable than in the animal world,—for the life of plants is not in water exposed to destructive accidents, like that of animals. And in its proceeding and re-

* Prof. James Hall, with remarkable foresight, obtained through his intimate acquaintance with the distribution of the Palæozoic fossils, remarks in his report (loc. cit. p. 83) that species of Fucoides of the group of the *Cauda-galli* might perhaps be found in the Lower Coal Measures of Pennsylvania.

ceding periods the sea brings with it and disseminates the seeds and branches of its Hydrophites, which germinate again, reproducing identical forms wherever circumstances are favorable to their development. But that terrestrial plants, like those of which the coal is a compound, should have been exposed to some modification of life after each of those revolutions, which so often totally changed the surface of the land during the Carboniferous epoch, is an assertion which can only be considered reasonable. For each of these revolutions may have influenced the atmosphere, either in its degree of density or of humidity, or in its chemical compounds. Moreover, each of them at least has evidently modified the land-stations inhabited by the plants, either by leaving the surface more or less penetrated with humidity, or by covering it with deposits of another nature, or with other elements of vegetation, sand, lime, mud, &c.

This assertion does not force us to the conclusion that all the plants of the Coal Measures have been totally destroyed after each submersion of the land, and been replaced by other species; but only that some of the predominant species have lost in the number of their representatives; that a few have disappeared, while new kinds have taken their place; and that accordingly, for any particular horizon, the group of vegetation has a character which may be recognized in its fossil remains, and serve as a true and reliable guide for the identification of the coal strata.

This is not said as a reaffirmation of a personal opinion expressed elsewhere.* For, with a few exceptions, all the authors who have studied the fossil plants of the coal, in relation to their habitat, have come to the same conclusion. Prof. Brongniart's remarks on this subject are worth recording. He says:† "But if the vegetation of our earth has been maintained without great changes during this whole period of time (the Carboniferous epoch), it is not the less certain that very marked changes in the species may be observed during the deposition of the various strata. Thus, in one and the same coal basin, each bed has characteristic species which are not found in more ancient or more recent strata, and which the miners themselves recognize as peculiar to a coal bed." Another celebrated European palæontologist and botanist, Prof. W. P. Schimper, of Strasbourg, records the same fact in a recent work, saying‡ that in the same coal basin a variation of species is observable in passing from the inferior to the superior strata. So remarkable is this change that the highest strata of the true Coal Measures are marked already by species which, like *Pterophyllum*, are characteristic of the Trias, or even of the lower Jurassic formations.

Though the researches on the palæontological botany of our American coal fields are only in an incipient state, and thus our acquaintance with the leading species of various

* American Journal of Sciences and Arts (2), vol. 30, p. 367, Geological Reports, &c.

† Tableau des Genres (1849), p. 95.

‡ Terrains de Transition des Vosges, Partie Palæontologique (1862), p. 318.

horizons is very limited, the value of what is known already and applied to the identification of strata is demonstrated and strengthened by every new discovery.

§ 8. DOES PETROLEUM ORIGINATE FROM THE DECOMPOSITION OF MARINE PLANTS?

Considering the question of the origin of our deposits of petroleum, some geologists have expressed the opinion that they might be due to the decomposition of marine plants, as coal is the result of the decomposition of a terrestrial vegetation. This conclusion is but natural, for there exists an evident correlation between the formation of both kinds of deposits of bitumen. But this relation cannot be, or at least has not yet been, established by direct proofs or experiments, and that is probably the cause why the subject has not been studied more in detail.

§ 9. FECUNDITY OF THE MARINE VEGETATION AT THE PALÆOZOIC AGES.

There is no doubt that the marine vegetation of the Palæozoic ages can be compared, for luxuriance, and in some measure for its composition also, to the terrestrial vegetation of the coal epoch. From the Upper Devonian down to the Lower Silurian, some strata of shales are not only covered, but indeed filled, sometimes for hundreds of feet in thickness, with fossilized forms of Hydrophytes. These evidences of a primordial vegetable world are far more numerous than the remains of land plants in the shales of the Coal Measures. Nevertheless, they appear to belong to plants of a soft tissue, mere cellular, probably mostly uncellular vegetables, the debris of which had not by much the same chances of fossilization.

The superabundance of vegetation testified by fossil remains in Palæozoic ages is in accordance with one of nature's most evident laws. The amount of carbonic acid gas is acknowledged to have been, at the Palæozoic times, far greater in the atmosphere, and also in the water of the seas, than it is now. The prodigious luxuriance of the vegetation of the coal period is rightly ascribed to this fact. It cannot be supposed that in the sea the vegetation, which is there also the intermediate agent between animal life and unorganized bodies, gaseous or mineral, should have been in a diminutive state when its action was the most in demand, like its development, for the purification of the water and the transformation of the superfluous carbonic acid gas into organism and oxygen.

We have no proofs from fossil remains that the Hydrophytes of old attained a very large size. The largest circular fronds of *Fucoides Cauda-galli* show a diameter of about one foot; the greatest length of the branching Fucoides in the Chemung is from two to three feet. But we cannot judge all the vegetable representatives of an epoch from a few fossilized specimens. These may have belonged to a species of a more compact organization, or to some kind of Corallines, which had their surface covered with a hard crust of lime, while other groups of a soft, mere cellular tissue, which had representatives of large size, have been totally decomposed and destroyed. There is no need however of this hypothesis, on the size of the Palæozoic Algæ, to argue by comparison on the fecundity of

the marine vegetation of old. Small species of Hydrophytes, in our time, afford sufficient analogies. The great bank of *Sargassum*, which extends between the 20th and 45th parallel of latitude, covers, according to Humboldt's computation, a space of more than 260,000 square miles. In places this floating bank is so thick as to arrest the progress of vessels, and it appears at present to be of the same extent and to occupy the same place as when it was first noticed by navigators. What can we then infer to have been the result of a vegetation whose force was at least double of what it is now, and which has written its history in whole strata of great thickness?

§ 10. ANALOGY OF LIFE AND FUNCTIONS IN BOTH THE TERRESTRIAL AND THE MARINE VEGETABLE WORLD.

It cannot be presumed that this whole vegetable world of Palæozoic seas has left nothing after it but useless petrified remains. In the march and development of nature's productions, nothing of the materials employed is ever lost. The smallest atom of matter is preserved in some way, if not constantly remodelled. Thus we find the key of a new life, of a new creation, in the remains of a destroyed one. Thus, some leaves, preserved by fossilization, in the shales of the Coal Measures, open to our view not only the whole world of an ancient vegetation, but its predestinated result, coal deposits, slowly laid up by its agency. Thus also the remains of marine plants, in the shales of the Devonian, point out, I think, not only the fecundity of an ancient marine vegetation, but its result in the contemporaneous deposits of petroleum. Indeed, both kinds of vegetation have great analogy of life, if not of organism. The plants of the coal, by their structure, the form of their long pointed leaves or indefinitely divided fronds, were shaped for the absorption and the transformation from the atmosphere of the greatest amount of carbonic acid gas into woody tissue. The Chlorosperm of the Palæozoic times, with their simple bladdery conformation and their green color, were undoubtedly prepared to perform in the water the same functions as the coal plants performed in the atmosphere. As the result of terrestrial vegetation has been, first woody tissue, and then, by its decomposition, coal, so the result of marine vegetation has been, first cellular tissue, filled with a kind of liquid carbon, and as the carbon is unalterable, the decomposition of the plant has left it free as fluid bitumen or petroleum.

§ 11. WHAT CHEMISTRY INDICATES ON THE SUBJECT.

We cannot follow, in our day, by means of the accumulated remains of Hydrophytes, the slow process of carbonization, and compare its results at different stages of its development, as we can by help of the remains of land plants, in the formation of peat bogs, lignites, &c. This only has been observed: When marine vegetables are thrown upon bogs and mixed with terrestrial plants as compound of the peat, they do not leave any trace of organism or primitive form, and the peaty matter, then of a deeper black color, is a softer, more homogeneous compound, richer in bitumen. When, detached by storms or tides, Algæ

are heaped in great masses on sandy shores, they promptly decompose, passing first to a black, soft paste, and then to a glutinous fluid of the same color, which exhales a strong disagreeable odor, and penetrates the sand. Chemistry has not analyzed these matters resulting from the decomposition of Hydrophytes, nor even species of marine Algæ;* and therefore it is not proved that there exists a direct relation between them and petroleum. Chemistry demonstrates, however, that petroleum and coal are both compounds of the same elements; and the former matter being proved of vegetable origin, the second is necessarily, by induction, referred to the same.† And as some substances, like iodine, which was formerly procured from marine plants only, are now more abundantly obtained from petroleum, chemical analyses, I think, confirm in that way the relation between petroleum and Hydrophytes.

Though chemistry is not directly interested in it, it is but right to refer here to a peculiar fact which bears upon the subject. The Algæ, especially the group of the *Caulerpæ*, feed some of the animals of the seas, remarkable for the size and the prodigious fatness of their bodies. The green fat of the turtles, says Harvey,‡ so much prized by aldermanic palates, may possibly be colored by the unctuous green juice of the Caulerpæ, on which they browse. The same could be said of the color of the Devonian petroleum, which is exactly that of the Chlorosperm Hydrophytes. It is not positively ascertained, I believe, if whales and other marine mammifers of this kind, whose bodies are large reservoirs of oily matter, are true Algæ-feeders; but when killed, the stomachs of these animals are always found mostly filled with marine weeds.

§ 12. GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF PETROLEUM DEPOSITS AND FUCOIDAL REMAINS.

A last argument, no less conclusive on the subject, is taken from the geological and also from the geographical relation between deposits of petroleum and Fucoidal remains.

Oil-bearing strata are seen in the Coal Measures mostly inferior to the big bed of coal No. 1, which is often a cannel coal; and sometimes also, but rarely, at a higher horizon, as, for example, below coal No. 3, and also coal No. 12, generally in more or less evident connection with cannel coal. This has probably led to the opinion, still admitted by some geologists, that all the deposits of petroleum owe their origin to a slow decomposition of coal, under some peculiar influences. As there has not heretofore been observed any indi-

* Prof. Liebig, to whom I wrote a *résumé* of my opinion on the subject, with the request that he would point out to me the result of chemical analysis of marine plants, if there were any, either in support or discredit of my ideas, kindly answered: "That there were unhappily no analyses of species of Fucus, or of other Hydrophytes, which could be used as affording support to my views. But that my arguments, based on exact researches, were so conclusive, that for himself, at least, they had removed any doubt of the truth of the theory."

† See, on this subject, a very remarkable and most instructive paper, by Sterry Hunt, in the American Journal of Science and Arts (2), pp. 156 to 171.

‡ Loc. cit., vol. i, p. 31.

cations that remains of marine plants might have existed at some places mixed with the aerial plants of the bogs of the coal epoch, it was not easy to account for such a phenomenon as that of the formation of coal and petroleum at the same horizon and under the same circumstances. But this curious fact, I think, is explicable now. When the combustible matter has been formed especially from the remains of aerial plants, whose tissue was mostly vascular, or vascular and cellular, like that of the *Lepidodendron*, *Sigillaria*, ferns, etc., it becomes by mineralization a hard coal, with thin layers or distinct laminas, sometimes shining, sometimes mixed with opaque layers and flakes of charcoal, and giving, by combustion, a proportion of ashes according to the nature of the wood. When it has been formed merely by floating fresh-water vegetables, like *Stigmaria* and its leaves, the compound, originally half fluid and more easily decomposed, becomes, by the slow process of combustion, compact, homogeneous, without apparent layers, tending to mere bitumen, thus forming the different varieties of cannel coal. Now, I believe that when this floating vegetation has been more or less densely intermixed with marine plants, and perhaps also influenced by marine water, the almost total absence of woody fibres has casually prevented the bedding of the material, and so, by slow maceration, part of it has been transformed into fluid bitumen. It is probably for this reason that we see, sometimes, as at Breckenridge, in Kentucky, a bed of cannel coal so nearly decomposed into petroleum that it can scarcely be used as coal, and at a lower level, even in close proximity, and where every trace of coal has disappeared, inferior strata of sandstone, strongly impregnated with petroleum.

In descending from the base of the Coal Measures into the Devonian, we find deposits of oil nearly in the whole thickness of this formation, with the exception of the old red sandstone, equivalent of the Ponent and part of the Vespertine of Pennsylvania. All the plants of this formation, and they are numerous enough, belong to swamp or land plants, and no trace of petroleum has been seen in these measures. But down from this red sandstone, the Chemung is full of remains of Fucoides, and where they are found all the sandstone strata of this formation are more or less impregnated with oil.

Still lower the black shales of the Hamilton group are so much charged with bitumen that they have often been considered as the true source of the Devonian petroleum. There the remains are nearly, almost totally, obliterated. A few teeth of fishes and small shells, very rarely large trunks of *Lepidodendron*, nothing more, at least in those extensive deposits, generally of great thickness, which border our Western coal basins. The color of these shales, and the bitumen which they contain, indicate a formation under water, under the influence of a powerful vegetation; and a marine vegetation, without doubt; else, besides the well-preserved trunks of *Lepidodendron*, which have probably been brought floating, we should find there other remains of aerial plants. At Worthington, in Ohio,

where I have spent much time in searching for fossil remains in these black shales, I have seen them often covered with round spots of coaly matter, varying in diameter from half an inch to one foot, showing no trace of organism, and resembling some kind of round, hard Ulvaceæ, like those which are seen in great quantity attached to the muddy shores in shallow water.

Descending further down in the Lower Devonian and Upper Silurian, we see there also the rocks saturated with petroleum, and generally marked by an abundance of Fucoidal remains. It is probably from the rocks of the Upper Silurian that Prof. Brogniart obtained his Fucoides from Canada. In Ohio and other Western States, where the Upper Silurian limestone is barren of remains, it does not show any deposits of petroleum. In Canada the same rocks have both Fucoides and fluid bitumen. Prof. Lesley, after an examination of the east end of Canada, Gaspé, wrote me (5th January, 1866): "All sorts of marine vegetation of Upper Silurian and Devonian ages seem there in great abundance, and petroleum everywhere in the Devonian, and oozing from the lower Helderberg limestone formation."

Still deeper the Lower Silurian has small deposits of bitumen in cavities of limestone, even when every trace of organism has disappeared. This fact again is, I think, another indication of the relation of petroleum to a marine vegetation. For it is well understood that vegetable life has ruled the seas in its minute representatives, Diatomaceæ, Desmidiaceæ, long before animal life could be supplied or sustained by it. These diminutive and primitive oil reservoirs are attributable to the concentration and decomposition of a local surplus of that primordial vegetation.

The geographical distribution of petroleum and that of the remains of marine Algæ present the same remarkable coincidence. At Oil Creek, Slippery Rock Creek, in the Chemung of Virginia, Ohio, Kentucky, everywhere indeed where oil has been seen, either in cavities or saturating the rocks, and where the strata were open to view, a remarkable amount of Fucoidal remains has been observed. This cannot be a mere casual coincidence.

The discussion presented in the last part of this paper may then be closed by this assertion: That though the theory of the origin of petroleum from marine vegetables is not yet supported by direct experiments and conclusive proofs, the reasons in favor of it are weighty enough to merit due consideration. The more so, that if recognized true, the theory presents an important chapter of the history of petroleum, and may prove of great value in its application.

ARTICLE XI.

NOTES UPON THE GEOLOGY OF SOME PORTIONS OF MINNESOTA, FROM ST. PAUL TO THE WESTERN PART OF THE STATE.

BY JAMES HALL.

Read June 15, 1866.

During the months of June and July, 1865, I had an opportunity of examining some parts of the State of Minnesota, the geology of which has not heretofore, so far as I am aware, been fully described or understood.

After returning to St. Paul from an exploration of the St. Croix River, an occasion was offered of going out to the central and western parts of the State, to examine some reputed coal mines. This part of the country was beyond the limits of the settlements, and supposed to be subject to the incursions of hostile Indians. There were at that time, beyond the settlements, two ranges of stockades, about fifteen miles distant from each other, at each one of which were stationed a number of mounted men. Beyond these were scouts' camps; the most westerly of which was at Lake Shetek, near the borders of Pipestone County. It was not deemed prudent to undertake the journey without an escort, and General Sibley, the commander of that military district, very kindly gave an order to Col. Pfaender, commanding officer at Fort Ridgely, upon the Minnesota River, to furnish a mounted escort sufficient to protect the party in the journey west from the Minnesota River. Fortunately Mr. Henry Back, the chief of scouts, was at Fort Ridgely on our arrival there; and through the kindness of Col. Pfaender, he was placed in command of the escort.

The geology from St. Paul westward to St. Peter is monotonous and barren of especial interest. Leaving the Lower Silurian limestones of the Trenton, Black River, and Birdseye formations, we descend at Fort Snelling to the friable and often incoherent sandstone, denominated by Dr. D. D. Owen, St. Peter's sandstone, and which, in the western series, holds the place of the Chazy limestone in eastern localities. From this place to St. Peter we find exposed at intervals the Calciferous sandstone or Lower Magnesian limestone, with the Potsdam sandstone beneath,—while the surface is marked by accumulations of sand from the destruction of the St. Peter's sandstone above; and there are at some points indications of remaining outliers of the same rock. At St. Peter the second river-bottom, or terrace, is underlaid by the Lower Magnesian limestone, which is quarried for a building

stone. Beneath this is the Potsdam sandstone, which is exposed at a few places. At one point on the southwest side of the river, there is still a little of the St. Peter's sandstone visible above the Lower Magnesian limestone. The valley of the river is occupied by the Lower Magnesian limestone as far as Mankato at the bend of the Minnesota, beyond which I have not seen the formation.*

Taking the road from St. Peter to New Ulm, we ascend from the plateau over a slope, composed of northern drift with numerous boulders of crystalline rocks, to the level of the high prairie, which continues with moderate undulations and a few deeper ravines, nearly to the Minnesota River. Approaching within about three miles of the river along this road, there rises to the surface a reddish-brown crystalline rock, having a granitic aspect, but which when critically examined is found to consist mainly of quartz, or of quartz and feldspar, without the perceptible admixture of other minerals.

The rock is cut vertically by numerous joints, the walls of which are sometimes separated or worn into wide, deep fissures. There are no distinct lines of stratification, and from its appearance on the prairie it would be difficult to indicate either stratification, dip, or direction, to the mass. It continues with scarcely an interruption to the east bank of the Minnesota below New Ulm, at the Redstone Ferry. Here, under a more careful examination, the true character of the rock is disclosed, and the top of the hill is found to be essentially a metamorphosed quartz rock, or conglomerate, succeeded below by a more compact quartz rock; with some of the beds sienitic. This graduates below into a compact purple, and finally reddish quartz rock, in distinct layers, which soon become alternated with shaly seams.

A section made from the river margin about a quarter of a mile below the Ferry, gives the strata shown on the opposite page in a descending order, from a point about 125 feet above the river.

We have therefore an almost continuous exposure of the strata for more than one hundred feet in thickness. There is a distinct dip to the northeast,† which in the lower beds amounts to twenty or thirty degrees, while the general trend of the outcrop is to the westward or northwestward.

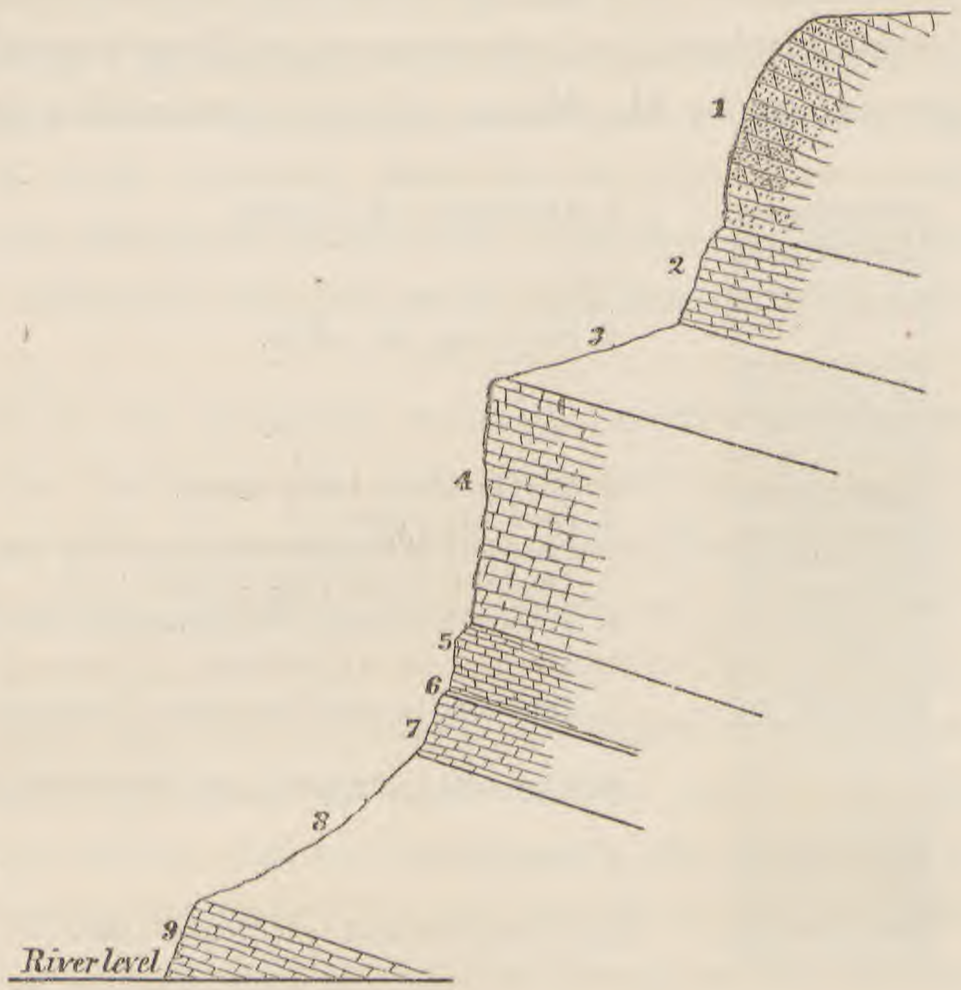
We have here an opportunity for observing, in the most satisfactory manner, this interesting fact,—that while the lower beds of the formation are scarcely or not at all metamorphosed (the lamination and alternations of soft shaly matter being as clearly defined

* Dr. D. D. Owen, in his Geological Map, has colored Potsdam sandstone as far as the mouth of the Big Cottonwood River; but this was probably the work of his assistants, who explored the Minnesota River; and my own investigations do not confirm this view.

† The dip, by the magnetic needle, is northeast by north; but making the allowance for variation, the true dip is about northeast.

as in any formation), the higher beds have nearly or quite lost all traces of their sedimentary origin, and might readily be classed among "granitic uplifts or intrusions of metamorphic rock."

1. Heavy-bedded gray or reddish and whitish-gray coarse quartzite, with vertical joints and obscure lines of bedding. The weathered surface showing a conglomeratic character; 30 ft.
2. Thinner-bedded and fine-grained quartzites; 15 ft.
3. A hiatus, slope covered by soil about 10 ft.
4. Compact purplish crystalline quartzite, graduating downward into more reddish quartzite; about 35 ft.
5. Reddish quartzite in thin, sometimes slaty, layers; 10 ft.
6. An irregular seam of red clay, of 2 to 4 inches.
7. Thinly laminated quartzite in alternating layers of 6 inches to 2 feet thick, each one separated by partings of shale or clay; the whole red and mottled, with yellowish-white surfaces, with ripple marks; about 8 feet to bottom of quarry.
8. Slope covered by talus and rubbish from quarry; about 20 ft.
9. Thinly laminated quartzite, which in some bands is brittle and friable; layers all mottled with cream-colored spots or irregular stripes; about 12 ft.



The lower beds taken together are variegated; but many of the layers throughout are of a deep brick-red color. In the higher part of the formation some of the beds for a considerable thickness are of a grayish-white, or as nearly white as such formations usually are. Still, however, the prevailing color of the mass is reddish-brown.

Taking into account the rate of dip, which is probably a little less in the higher than in the lower beds, I estimate that the entire thickness of strata, visible above the river level to the point of disappearance beneath the prairie, is not less than fifteen hundred feet, and may be considerably greater than this.*

Following the course of the river from New Ulm to Fort Ridgely, there are several exposures of reddish-brown "granite" or quartzites, which has been quarried in a few places, but I do not feel entirely sure of its connection with the rocks in the prairie or at the Ferry below.

Proceeding westward from Fort Ridgely, I had no opportunity of seeing any other formation than the prairie for about thirty miles. At this point near where we crossed

* Estimating the thickness from the dip observed near the river level, it would be more than 3000 feet.

the Big Cottonwood River, there is an exposure of rock in the bank of the stream; and at a short distance further on, some explorations had been made for coal, and a shaft had been sunk to the depth of more than one hundred feet. The materials thrown out of this shaft consisted of a dull greenish argillaceous sand, with calcareous nodules, together with irregularly laminated sandstone containing vegetable remains. The order of deposits, as given to me by Mr. Morin, who superintended a part of the working, was as follows:



1. Ironstone; 1 ft. 6 inches.
2. Sand, clay, etc.; 40 ft.
3. Earthy coal;* 1 ft. 8 inches.
4. Sand, clay, etc.; 3 ft.
5. Sandstone in irregular and diagonally laminated layers, with sometimes calcareous concretions, and containing plant remains; 5 ft.
6. A calcareous sandy clay of variable color and character; 20 ft.
7. Sandstone in loose thin layers of three or four inches; 4 ft.
8. Clay with coaly seams near the bottom; 16 ft.
9. Clay; 13 ft.
10. Loose quicksand to bottom of shaft.

In the river bank, at a quarter of a mile distant, and at a level 30 or 40 feet below the ground where the shaft began, there is the following exposure:

1. Loose ironstone† in nodules and irregular concretions, more or less mixed with drift and pebbles; 1–2 ft.
2. Calcareous clay; 6–8 ft.
3. Earthy coal; 8 inches.
4. Clay as above coal; 4 inches.
5. Yellow or ferruginous sand and clay; 3–3½ ft.
6. Ferruginous sandstone in irregular layers and diagonally laminated, to level of river; thickness unknown.

This sandstone appears to be the same as that containing plant remains met with in the shaft; and though I did not find plants in it at this point, I was informed that speci-

* An analysis of this coal, by Prof. T. Sterry Hunt, gave the following results:

Fixed carbon, ...	26.1
Volatile matters, ...	25.7
Ash, ...	48.2——100.0

In the sections of strata near the mouth of the Redwood River, there is a stratum of similar earthy coal three feet thick.

† This ferruginous layer does not appear to belong to the regularly stratified deposits, as it overlies, irregularly, the edges of the successive beds, and has been deposited after the denudation had taken place.

mens had been found there; and at another place on the Cottonwood I found them to be quite common. Near the previous exposure, and partly from an old digging, I obtained a similar section. At still another point I noticed a similar exposure, leaving no doubt of the character and order of arrangement of the materials composing this formation.

The character of the vegetation obtained from the sandstone of the shaft and elsewhere, resembling the leaves of Salix, Poplar, Liriodendron, Tupelo, etc., induced me to refer this formation to the Cretaceous period. A single indistinct shell was the only animal fossil I was able to obtain. The aspect of the calcareous concretions is similar to those from the Cretaceous formation of the Upper Missouri; and the green argillaceous clay is likewise similar.

Leaving this place on the Cottonwood, we proceeded westward on the low prairie, crossing Mount Creek, going towards the sources of the Little Cottonwood; when at a point ten or twelve miles from the place of the last examinations on the Big Cottonwood, we came to an abrupt elevation in the prairie, the upper part of which presented a vertical escarpment of red quartzite, which trends northwest and southeast, dipping to the southwest. The surface of the rock above was nearly destitute of vegetation over several acres, and presented a most beautiful exhibition of ripple-marked layers. On its higher exposed surfaces the rock is thinly bedded, and easily separated into laminæ often an inch or less in thickness. In the larger exposures it is red, grayish, or mottled, and in all essential characters is similar to the lower beds at Redstone Ferry, on the Minnesota.

It is impossible to resist the conclusion that we have here the eastern outcrop of strata similar to those at Redstone Ferry, and which, dipping in opposite directions, have once been continuous across this interval of forty miles, originally forming a great anticlinal axis, which has been eroded to an unknown depth, and subsequently partially filled with the deposits of cretaceous and other modern formations.

This outcrop, forming a sort of terrace, is the commencement of the Coteau des Prairies; and I am informed by Mr. Back, the chief of scouts, that he has traced this rock, sometimes uninterruptedly, for twelve or fifteen miles, and that it is constantly rising to the northwestward. From the point where I stood, the course of the outcrop could be traced for many miles towards the northern limits of Iowa. Farther away to the northwest, the great table land of the Coteau des Prairies rises several hundred feet above the prairie on the east.

I was also informed by Mr. Back, that the famous Pipestone locality presented an escarpment precisely like the one on which we stood, except that the strata were dipping to the eastward; that the upper beds are hard and quartzose like those we examined; and that the pipestone is at a lower level, of about eighty feet below the crest of the outcrop.

This offers a clear and unmistakable evidence of a rock of the same or similar formation, which I can have no doubt is the western outcrop of the synclinal axis which occupies a width of sixty or seventy miles. I was the more convinced of this after proceeding thirty miles to the westward as far as Lake Shetek, without any evidence of other geological formations except the prairie drift covering the quartzite.

At this place I was so fortunate as to find a large quantity of pipestone, which had been brought from the original locality the previous winter, and I observed among this material a considerable variety of color and texture; but in its red and mottled aspect, it is precisely similar to the softer portions of the rock at Redstone Ferry on the Minnesota. Were there no other information concerning the position of the pipestone, its exact resemblance to the rock at Redstone Ferry would convince one of the identity in age of the formations in the two localities.

Turning northeastward from Lake Shetek,* I explored the upper branches of the Cottonwood River, without finding any satisfactory evidence of other geological formations. Proceeding down the river as far as Saratoga,† the locality of a former settlement, which is now abandoned and the buildings destroyed, I found no features of especial geological interest. From Saratoga we proceeded almost directly north to Sun Lake, and thence crossed the undulating prairie country to the Redwood River; and thence down that stream to Redwood Falls. At intervals on the way we found evidence of the existence of the same green clay and sand formation as that observed upon the Cottonwood below the mouth of Mound Creek. At Redwood Falls a well has been dug, which penetrates a similar formation; and the water has the same disagreeable taste, and is charged no doubt with the same salts which render the well-water in that region unpalatable. The same or a similar formation crops out at several points near Redwood Falls. In these localities, the earthy coal, of a character similar to that on the Cottonwood before mentioned, has a thickness of nearly three feet. An exposure of the same on the land of Mr. Flynn below

* The authority to be furnished with an escort had expressed the object to be for explorations upon the Cottonwood Valley; and I did not feel at liberty to go beyond Lake Shetek, though the men were very anxious to go to the Pipestone, and several of the scouts from the camp at Hurricane Lake and Lake Shetek volunteered to accompany us. It was therefore with great regret that I abandoned the idea of visiting that famous locality. A few days later, it was ascertained that eighty lodges of the Yankton Sioux were encamped at the Pipestone quarry.

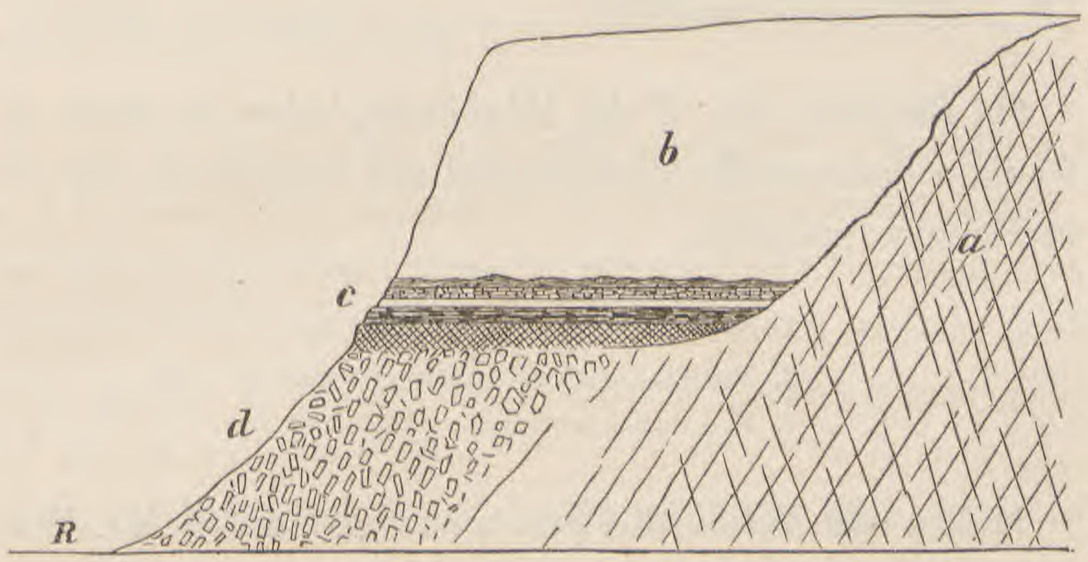
† All the settlements, except those near the Minnesota River, were either destroyed by the Indians in 1862 or have since been abandoned. This place was named Saratoga in reference to some copious springs, one of which I examined and found to be a fine chalybeate water. I was informed of other saline or alkaline springs, but the time at my disposal, together with the caution then necessary to be observed in this region, prevented any examinations beyond those having relation to the general geological features of the country.

the village of Redwood Falls (which had lately been sold as a coal property), gave the following section:

1. Prairie formation of sand and gravel, etc.; 60–70 ft.
2. Clay, varying from 4 to 6 or 8 ft.
3. Sandstone; 8 inches to 1 ft.
4. Dark clay shale; 2½ ft.
5. Sandstone; 1 ft.
6. Earthy coal; 3 ft.
7. Sandstone and cherty bed; thickness unknown.
8. Slope (talus) to river bed, about 70 ft.

The formation in this neighborhood evidently lies in depressions in the older strata of the Gneiss and Granite rocks, which rise up to a higher elevation than the Cretaceous deposits.

a. Gneiss and Granitic rocks of Laurentian age.
b. Prairie formation.
c. Clay, sand, and earthy coal, Cretaceous.
d. Talus to the river level.



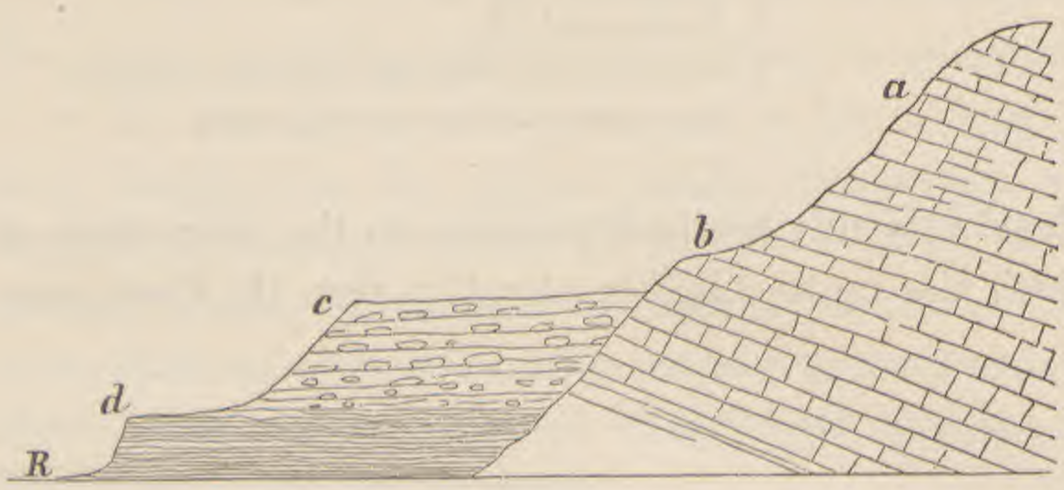
At another place three miles south of Redwood Falls, I saw outcrops of a similar formation at two localities a mile apart. The order in descending was as follows:

1. Prairie formation; 60 to 70 ft.
2. Clay of variable thickness; 3 to 5 ft.
3. Earthy coal; 3 ft.
4. Cherty concretionary rock; 4 ft.
5. Talus; 70 ft.

Both at Redwood Falls and along the river below, as well as in the valley of the Minnesota River above the mouth of the Redwood River, and upon the east side of the Minnesota at the mouth of Beaver Creek, the rocks are of a gneissoid character, resembling those of the Laurentian system. In many places these rocks are intercalated by steatitic or glauconitic beds, and the entire mass is in a state of decomposition to the depth of eighty or one hundred feet. Notwithstanding the numerous exposures, I was unable from the debris of the decomposing surface (with the very limited time at my disposal), to determine satisfactorily the structure of this portion of the country. It would be of much interest to ascertain the relation which the dip and direction of these older gneissoid rocks bear to the succeeding quartzites, which evidently belong to the Huronian system.

Returning again to the Minnesota River below New Ulm, I examined both the east and west banks of that stream. On the east side a little way above the Ferry, there

is a concretionary limestone of peculiar character, cropping out about fifty feet above the river level, and abutting directly against the outcropping edges of the quartzite, as shown in the section.



a. Gray and reddish-gray quartzites, with obscure lines of bedding, and numerous vertical joints.
b. Purplish or reddish quartzites, becoming brick-red, and thinly laminated below.
c. Concretionary limestone, horizontally stratified, and lying against the uplifted edges of the quartzites.
d. Red and variegated marls.
R. River level.

On the west side of the Minnesota, below or south of the mouth of the Cottonwood, I found a horizontally stratified red and variegated marl, with thin interrupted layers of concretionary limestone.

1. Soil of bottom prairie; 2 to 4 ft.
2. Red clay with calcareous concretions; 4 ft.
3. Red marly sandstone with calcareous concretions in continuous layers; 10 ft.

Half a mile below this point, on the farm of Mr. Winkleman, I obtained the following section:

1. Soil of bottom prairie; 2 to 4 ft.
2. Concretionary limestone in irregular layers, with seams of clay or marl; 10 ft.
3. Greenish or red marl; 1 ft.
4. Heavy-bedded concretionary limestone; 2 ft.
5. Marl, green and reddish, with concretionary layers to river level.
6. Continuation of red marls and concretionary limestone layers to the depth of 65 feet from the surface, as determined in the digging of a well.

A well dug at a little distance from the margin of the river, sixty-five feet deep, penetrates the limestone and ends in the red marl and sandstone below the level of the river.

The plateau or river bottom is about three-fourths of a mile wide, and comparatively very level. Beyond this the country rises in a pretty abrupt slope to the level of the high prairie. About five miles west of New Ulm, and seven or eight miles above the mouth of the Cottonwood, and where the river flows in a depression considerably below the level of the high prairie, I found the ferruginous sandstone,* with coaly matter in the

* This locality was pointed out to me by Mr. Back, who has proved himself a good observer of the country over which he has travelled.

clay above it, and containing the remains of plants, as at the localities on the upper waters of the Cottonwood, thirty or forty miles to the westward. The rock was exposed for some ten or twelve feet, and I have no doubt but the same argillaceous and arenaceous beds which are found below it on the Upper Cottonwood, lie beneath it at this place, and will be found filling the interval between the sandstone seen here and the concretionary limestone at Winkleman's farm, in the following order:

1. Clay and soil with earthy coal; 4 ft.
2. Ferruginous, irregularly bedded sandstone with layers of plants, etc.; about 10 feet visible.
3. Slope (covered) to bottom prairie, probably covering the soft clays and sands which are penetrated in the shaft on the Upper Cottonwood; 60 ft.
4. Level of bottom prairie; 40 to 45 feet above the river level. Concretionary limestone with intercalated beds of marl; 13 ft.
5. Red clays and marls with bands of concretionary limestone to river level.

The question may recur as to the age of these lower beds, which possess a character so entirely unlike the greenish clays and sands of the formation of the Cottonwood valley. The color of the marls is similar to that of the lower exposures of the quartzite, being red or brownish-red, with spots and stripes of lighter color, giving a variegated aspect; and the material was in all probability derived from the denudation of these ancient beds, which became more argillaceous in their lower members.

The concretionary interrupted layers of limestone in the marl gradually give place to the heavy concretionary mass of limestone above, which is likewise interstratified with greenish and red marls.

In the absence of organic remains, and without a knowledge of the immediately subjacent strata, it would be injudicious to assign positively a geological age to these beds; still, since they are apparently directly beneath the deposits which I have referred to the Cretaceous, I infer that they may be not older than the Triassic formation; and probably the red marls and superincumbent limestones represent the interval from the close of the Palæozoic deposits to the beginning of the Cretaceous period.

This lower marl and limestone formation, as well as the clays and sands, together with the ferruginous sandstone bearing plant remains, occur on both sides of the Minnesota River from New Ulm northward; and I have received information of the same series considerably to the southward of this point. The ferruginous sandstone was seen by Col. Pfaender near Fort Ridgely on the east side of the river; and I have, since my return from there, been informed that he has found the earthy coal near the same locality. The formation is known to me as far north as the mouth of Beaver Creek; and I believe it will be found to underlie much of the country on the east side of the Minnesota, and between that river and the Mississippi.

Without going farther into detail at the present time regarding the character and distribution of these formations, we may, I think, deduce a few general conclusions respecting the geological structure of the country described.

I conceive it to be sufficiently demonstrated that the quartzites at Redstone Ferry, on the Minnesota,—those near the sources of the Little Cottonwood, extending thence north and south,—together with those of the escarpments of Pipestone and of the streams flowing into the Sioux River,—are of the same age. These quartzites I regard as of the age of the Huronian formation of Canada, and the quartzites of Wisconsin.

The eroded anticlinal is occupied, as far as we know, only by newer formations, from Redstone Ferry, near New Ulm, to its opposite side, forty miles distant; while at a point forty or fifty miles further north, the ancient Laurentian rocks appear in the bottom of this old erosion, and upon these the newer formations lie unconformably.

A section across the country would present the following features, on looking to the northward, and proceeding from east to west:

(*Geological section from the Minnesota River at New Ulm to the western limit of the State.*)



a. Quartzites east of the Minnesota, at Redstone Ferry, dipping eastward.

b. The outcrop of quartzites near the source of the Little Cottonwood, dipping to the westward.

c. The outcrop of quartzites at the Pipestone locality, dipping to the eastward.

f. The place of the Pipestone stratum.

d. The interval between *a* and *b* made by the eroded anticlinal, which is now occupied by Cretaceous and other modern formations, along this line.*

e. The lower country to the west of the Pipestone-locality, occupied by modern formations similar to *d*.

R. Minnesota River. R′. Sioux River.

The space between the upper two lines of the section is intended to represent the prairie formation.

The country between *b* and *c* is occupied by a synclinal axis of Huronian quartzites; and we have the western margin of another similar synclinal at *a*. We have therefore in this apparently undisturbed region of country most satisfactory evidence that the more elevated portions are occupied by synclinal axes; while the lower portions are the places of eroded anticlinals, as at *d* and *e*.

The space between *b* and *c* is the southern extension of the Coteau des Prairies, which,

* *Note from Section.* An east and west section forty miles to the north of this point shows the continuity of the Cretaceous formation interrupted by numerous prominences of the Laurentian gneiss.

in its northern prolongation, rises to the height of four hundred feet or more above the level of the prairie at its base; and I have every reason to believe that the structure and character of the northern portion is similar to that farther to the south.

I infer, moreover, that the high Coteau or Plateau, as represented on the maps between the James River and the Missouri River, will be found to be a synclinal of Huronian quartzites and other rocks of that period,* and that the modern geological formations of the valleys on either side are in eroded anticlinals.

It has heretofore been supposed that the palæozoic rocks extended into this part of Minnesota; but the existence of so large an area of Pre-silurian formations, and the relations of these rocks to the modern formations, would apparently preclude the extension of the older fossiliferous rocks in this direction.

In offering this brief sketch to the scientific public, I can only regret that time and opportunity could not have enabled me to give a more complete exposition of this part of the country. The few facts observed, however, may serve to direct observation, and in some degree, perhaps, modify our views respecting the extent of certain formations. I deem it of some interest to have determined that these, often isolated, patches (usually called uplifts) of metamorphic quartz rock, with frequently a granitic aspect, have a structure, stratification, dip, and direction, and that they may be incorporated in our maps in accordance to some system of geological and topographical expression.

In making my investigations in the neighborhood of Redstone Ferry, I have been much indebted for kind attention and valuable information to Mr. Francis Baasen and Mr. C. T. Clothier, of New Ulm, who volunteered to accompany me to several interesting localities, which might otherwise have escaped my attention, and who gave me information of other points of interest which for want of time were not examined.

* It has become very important in the study of the geological structure of the continent, particularly in its northern portions, to distinguish the highly crystalline rocks of the Huronian and Laurentian periods; since their accumulation and foldings, and subsequent denudation, have given rise to a different topography for each one.

NOTE.—The discovery of this great extension of the Cretaceous system to the north and northwest, combined with our previous knowledge of its distribution in the region farther to the west, induces the belief that the formation may at one time have been continuous; and even now in some parts of the country, the easterly exposures of these strata may be connected with those further to the west. Again; the extension of the Cretaceous deposits along the Mississippi Valley nearly to the mouth of the Ohio, and some beds of the same or a little later age in

the Ohio Valley, point to a former continuity of the formation over the ancient Mississippi Valley; while some teeth of sharks, etc., found in the débris between the points indicated, help to sustain this view.

The occurrence of supracarboniferous strata, containing the gypsum beds,* in the valley of the Des Moines River in Iowa, and which may be of Permian or Triassic age, or of both, suggests their synchronism with the red marls, marly sandstones, and limestones below the Cretaceous formation on the Minnesota River.

The great amount of erosion and denudation which has taken place in this region, can scarcely be appreciated from the surface aspect of the country. We now know that these later formations were deposited in valleys of erosion, many miles in width and hundreds of miles in length. These formations in turn have been eroded in the most extensive manner, but the work of destruction has in a great degree been hidden, owing to the friable nature of the deposits, which left no bold escarpments or abrupt valleys; but the whole has been toned down, with rare exceptions, to gentle undulations, and the surface covered by fine débris.

The evidence of this destruction of the Cretaceous strata, such as characterize the Minnesota Valley, is shown by the vast accumulations of the prairie formation of Illinois, Iowa, and Minnesota, in many localities of which the cretaceous sands can be recognized but little changed; while the earthy ligniform coal of the same formation, already mentioned, is thickly scattered throughout the deep accumulations.

* See Geological Report of Iowa, vol. i, part i (Report of A. H. Worthen, for 1856), page 175. Also pages 142–3 of same volume.

ARTICLE XII.

A CONTRIBUTION TO THE KNOWLEDGE OF THE FLORA OF THE COAL PERIOD IN THE UNITED STATES.

BY HORATIO C. WOOD, JR., M.D.,

PROFESSOR OF BOTANY, AUXILIARY MEDICAL FACULTY, UNIVERSITY OF PENNSYLVANIA.

Read September 21, 1866.

THE specimens upon which this paper is founded are all of them in the Cabinet of the Academy of Natural Sciences in this city. Much of the memoir is a review of several papers published some years since in the Proceedings of the Academy, and is the result of a careful reconsideration and study of the subject with the light of further specimens and new publications.

SIGILLARIA, *Brongt.*

S. SOLENE, *Wood.* Stem costate; ribs strongly convex, approximate, distantly irregularly striate, with a well-marked central groove or broad channel; leaf-scars situated in the groove, small, subovate; vascular scars situated near the smaller end, 3, the central a dot, the lateral linear, arcuate.

The central portion of the channel between the scars is finely and closely striated like chasing; at the position of the scars the groove is slightly widened; the lateral margins of the leaf-scars are not regularly curved, but have a faintly marked angle near the base. The distance between the scars is from five to six times their length. This species is allied to *S. rugosa* and *S. elongata;* it differs from both in the smallness of its leaf-scars and their remoteness one from the other. It also wants the rugosities of *rugosa.* When decorticated the ribs are very strongly striate.

S. solanus, Wood. Proc. A. N. S., vol. xii, 1860, p. 237.

The type specimen in the Museum of the Academy is very large.

S. CYMATOIDES, *Wood.* Stem costate; ribs very narrow; furrows distinct, rather broad, marked, as are also the ribs, in the decorticated state, with numerous close striæ; scars large,

somewhat elongate, almost as wide as the ribs, their lower half tumified, so as to give the appearance of grooves running across at an angle of about 60° to the stem; the space between the scars about half their length, closely chased with numerous transverse, very fine striæ; vascular scars, 3, the central a dot, the lateral linear.

When decorticated the vascular scars are represented by a large dot-like impression.

S. cymatoides, Wood. Proc. A. N. S., vol. xii, 1860, p. 520.

S. BRARDII, *Brongt.*

Syn. S. Menardii, Brongt. There can be no doubt that these two forms are merely different parts of the same plant. I have frequently observed specimens demonstrating this by having on different portions of their surface cicatrices presenting all the characters of the two forms; Prof. Lesquereux informs me he has also seen such.

Sub-genus ASOLANUS. *Wood.*

S. CAMPTOTÆNIA, *Wood.* Surface very closely and distinctly striate; striæ diverging from the leaf-scars, so arranged as to form two sets of columns, the individual striæ in each of which are parallel to the others of the same column, and at right angles to those of the neighboring columns. The striæ of one set appear much more pronounced than those of the other, owing to their opposite directions causing the light to fall on them differently. The leaf-scars are oval, sunken, transverse, with a more or less marked angle at their top. The vascular scar is a central dot, with apparently two lateral linear dots, which latter are obsolete on my specimens.

Asolanus camptotænia, Wood. Proc. A. N. S., vol. xii, 1860, p. 238.

S. ORNITHICNOIDES, *Wood.* Proc. A. N. S., vol. xii, p. 238, appears to be a good species. The figure (pl. 4, Fig. 6, Proc. A. N. S.), is characteristic.

SYRINGODENDRON, *Sternb.*

S. BISTRIATUM, *Wood.* Stem without ribs; bark thin; surface striate with coarse flexuous striæ and numerous similar finer ones; scars small, linear oval, disposed in pairs about eight lines apart.

The difference between the striæ is much more marked in the decorticated surface, as the large ones are on it much more pronounced than on the bark. This plant evidently bears the same relation to the ordinary Syringodendra that Sigillariæ of the sub-genus Asolanus

do to the true Sigillariæ. There are no ribs, and the scars have the peculiar form and the absence of vascular scars which belong to the genus Syringodendron.

Syn. S. bistriatum, Wood. Proc. A. N. S., vol. xii, 1860, p. 521.
Cabinet of the Academy. Locality unknown.

S. MAGNIFICUM, *Wood*. Proc. A. N. S., vol. xii, 1860, is probably a form of *Sigillaria catenulata*. Lindley and Hutton.

SOLENOULA PSILOPHLÆUS, *Wood*. Proc. A. N. S., vol. xii, p. 238. Prof. Lesquereux tells me that he considers this fossil as *probably* a decorticated specimen of *Syringodendron cyclostigma*, Brongt. I do not see how the two can be joined except by finding the specimens which present in different portions, the very different characters of each. The figure given (pl. 4, Fig. 3, vol. xii, Proc. A. N. S.), is characteristic.

GEN. LEPIDODENDRON, *Sternb.*

L. OWENI, *Wood*. Proc. A. N. S., vol. xii, 1860, p. 239. This species is closely related to *L. vestitum*, Lesq., but is probably distinct. The figure given of it (pl. 5, Fig. 1, Proc. A. N. S., vol. xii), is a good one, representing every character on the stone. I think I was mistaken in referring *L. aculeatum*, Sternb., of Owen's Geological Survey of Wisconsin, to this species.

L. URÆUM, *Wood*. Scars elliptical, somewhat rhomboidal, elongate and curved below and above, marked with transverse flexuous wrinkles; margin slightly raised; vascular scar subrhomboidal or subtriangular (in the one case having the basal angle pronounced, in the other the base merely convex with the remaining angle mostly obtuse), situated a little above the centre of the leaf-scar, impressed with three dots arranged in a curve near its base, the inner of which is linear and transverse; median line not very distinct but running the whole length of the scar,—above the vascular scar, smooth and furnished with a triangular expansion rivalling the vascular scar in size; below the vascular scar, crossed by many very heavy, transverse, flexuous wrinkles; appendages distinct, irregularly curved and of considerable length; tubercles oval, elongate, situated immediately below the vascular scar and close to the median line.

L. urœum, Wood. Proc. A. N. S., vol. xii, 1860, p. 520.

The total length of the leaf-scar, in our type, is $2\frac{3}{8}$ inches; from the lower end to the

top of the vascular scar, measures one and a half inches; from the top of the vascular scar to the upper end, fourteen-sixteenths of an inch. Through the kindness of Prof. Lesquereux, I have had access to the second volume of Sternberg's *Flora der Vorwelt*, and find that this plant is much more closely related to *L. aculeatum* than *L. caudatum*, Ung., to which I formerly supposed it related, having only Unger's short description to guide me. The principal difference between *L. aculeatum* and it, is to be found in the position of the vascular scar. From the bottom of the leaf-scar to the top of the vascular scar, is in *L. aculeatum* one inch and a half, and from the top of the vascular to the top of the leaf-scar eight-sixteenths of an inch, so that the relation of the two is as three to one, whilst in *L. urœum* it is as twelve to seven. Broad Top Coal Region.

L. DREPANASPIS, *Wood.* Leaf-scars large, rhomboidal with rounded angles and somewhat curved margins; margins narrow, very slightly elevated; vascular scars triangular or sub-rhomboidal, their transverse diameter much the greater, elevated above the general surface, furnished with three dots and situated near the apex of the leaf-scar; below them is a crescentic, shining slope, on which are placed the roundish tubercles; appendages parallel to the margin; median line nearly obsolete, but crossed by numerous short, transverse rugæ.

L. drepanaspis, Wood. Proc. A. N. S., vol. xii, 1860, p. 240.

LEPIDODENDRON ICTHYOLEPIS, *Wood.* Cortex thin, leaf-scars subtriangular, kite-shaped; vascular scar strongly elevated, rhomboidal, oval, with the ends acuminate, without internal markings, situated in the apex of the leaf-scar; appendages well marked, elevated; median line elevated, pronounced, smooth; tubercles wanting.

The elevation of the upper portion of the leaf-scar gives an appearance of imbrication, which suggested the name.

Lepidophloyos icthyolepis, Wood. Proc. A. N. S., vol. xii, 1860, p. 240.

L. DUBIUM, *Wood.* Cicatrices lanceolate, acuminate at the base and apex, strongly convex, cristate along the central line; margin very narrow, flexuous; vascular scar linear lanceolate, slightly enlarged in the middle, elevated.

L. dubium, Wood. Proc. Acad. Nat. Sciences, New Series, vol. xii (1860), p. 238.

This species is allied to *L. rimosum* and *L. undulatum* of Sternberg. It differs from

both in its linear lanceolate vascular scar, which is reduced to a mere median line; the cicatrices are more elongated, narrower than those of *L. undulatum*, but very similar to those of *L. rimosum*. When the bark is adherent the cicatrices appear only as distant ridges, which are in reality scarcely more than the vascular scars—the remainder of the cicatrix being hidden.

I have seen but a single specimen, which is in the Museum of the Academy of Natural Sciences. Whence it was obtained I am unable to state.

L. GIGANTEUM, *Lesq.*

L. ingens, Wood. Proc. A. N. S., New Series, vol. xii (1860), p. 239, pl. 6, Fig. 4.

L. ACULEATUM, *Sternb.*
L. mekiston, Wood. Proc. A. N. S., vol. xii, 1860, p. 239, pl. 5, Fig. 3.

L. OBOVATUM, *Sternb.*
L. Bordae, Wood. Proc. A. N. S., New Series, vol. xii (1860), p. 239, pl. 6, Fig. 3.

L. RUGOSUM, *Sternb.*
L. Lesquereuxii, Wood. Proc. A. N. S., vol. xii, 1860, p.

SIGILLARIA PERPLEXA, *Wood.* Proc. A. N. S., vol. xii, 1860, p. 237. This very odd specimen, which from its apparently having ribs, I referred to the genus Sigillaria, is evidently closely connected with the genus Lepidodendron, for on removing the bark, I find in one or two of the rectangular spaces the peculiar vascular markings of that genus. Prof. Lesquereux thinks it to be part of a young shoot of his *L. vestitum*. Is it possible that the apparent ribs are the result of accident? I give a figure, so that if any one should find a similar fossil he may know where to refer it to.

L. VESTITUM, *Lesq.*
L. rectangulum, Wood. Proc. A. N. S., vol. xii, 1860, p. 519.

L. SALEBROSUM, *Wood.* Leaf-scar rhomboidal; margin elevated, irregularly plicate, often quite flexuous; vascular scars triangular, placed in and filling up the apex of the leaf-scar; appendages apparent; internal dots and tubercles wanting; median line absent, but replaced by a strongly pronounced sub-central pit.

This species is allied to *L. vestitum*, Lesq., but is distinct by the remarkable dot

or pit which is in all the leaf-scars much more strongly pronounced than the vascular scar.

L. salebrosum, Wood. Proc. A. N. S., vol. xii, 1860, p. 520.

L. CHILALLÆUM, *Wood*. Leaf-scars oval, rhomboidal, acuminate at both ends, often elongated into a narrow communicating channel; margin distinct, broad, slightly elevated, alternately contracted and expanded for half the length of the scar; vascular scar deeply sunken, sub-rhomboidal, the transverse diameter much exceeding the height, often four times as great, without dots or internal markings; triangular marking above vascular scar distinct; appendages faintly marked; tubercles absent; median line well marked above the vascular scar, below almost obsolete but crossed by numerous very strongly pronounced rugosities.

L. chilallæum, Wood. Proc. A. N. S., vol. xii, 1860, p. 520.

L. DICROCHEILUM, *Wood*. Cicatrices rhomboidal elliptical, with the apex and base somewhat prolonged and acuminate, and the base flexuous; margin raised, broad, regularly flexuous; vascular scars sub-rhomboidal, with apex and base generally rounded and lateral angles acute, situated a little above the centre, but markedly to one side of the leaf-scar, internally marked with three dots, surmounted with a somewhat semilunar impression; the median line distinct, smooth; tubercles and appendages wanting.

L. dicrocheilum, Wood. Proc. A. N. S., vol. xii, 1860, p. 238.

The margins of our specimens so bifurcate that one side receives an offset from the margin of the neighboring scar; so that the margin for half the scar is alternately broad and narrow; thus the margin on the right hand side below is nearly twice the breadth of the right hand upper margin. The total length of the leaf-scar is seven lines, the distance from bottom of leaf to top of vascular scar five lines, from thence to top of leaf-scar two lines.

This species is very closely allied to *Sagenaria dichotoma*, Sternb., and if all the figures given in the *Steinkohlen Formation in Sachsen*, of Geinitz, t. iii, are really one species, I do not see how this can be retained as separate, although the shape of the vascular scar differs somewhat.

Hab. Broad Top. Roof of Cook's (upper) seam.

L. VENUSTUM, *Wood*. Cicatrices rhomboidal, with the bases and apices obtuse, rounded,

their whole surface covered with very minute granules, so that under the glass it presents the appearance of shagreen; vascular scar rhomboidal, with its lateral angles acute, its basal and apical angles acute or rounded, situated just above the middle of the leaf-scar, marked with three internal dots, the lateral of which are generally obsolete; tubercles small, somewhat obovate, the left one mostly obsolete, and when present, placed lower than the right; median line distinct below the vascular scar and crossed by three or four transverse wrinkles, above the vascular scar somewhat obsolete, but furnished with a triangular expansion which gives origin to a long flexuous line from each lateral angle; appendages distinct; margin very narrow and flexuous.

L. venustum, Wood. Proc. A. N. S., vol. xii, p. 240, pl. 5, Fig. 2.

This plant is very near to *L. obtusum*, Lesq., and may prove to be a young branch of it. I have not seen any specimens of that species, but presume that they lack the granulated surface, as it is not mentioned. There are also differences in the shape of the main scar, breadth of margin, appendages, and the upper triangular marking.

GEN. ASTEROPHYLLITES.

A. STACHYOIDES, *Wood*. Under the name of *Lepidostrobus stachyoides*, I described, Proc. Acad. N. S., vol. xii, 1860, p. 240, a fossil fruit, which is related to *Asterophyllites crassicaulis*, Lesq. As Prof. Lesquereux has shown, these fossils are, probably, nothing more than the fertile fronds of *Asterophyllites*. The nutlets are ovate or obtuse rhombic, the proximal more rhombic, the distal narrower, more ovate. The rachis is very much attenuated, linear. The leaves are long and linear, apparently but one below each nutlet.

GEN. SPHENOPHYLLUM.

S. LATIFOLIUM, *N. Sp.* Stem moderately thick, somewhat inflated at the joints, strongly sulcate. Leaves very large, apparently in whorls of four, thin, broadly triangular or wedge-shaped, their distal margin irregularly toothed; nervules very strongly pronounced, numerous, dichotomously forking.

Bowen's Collection, Cabinet of the Academy.

GEN. ANNULARIA.

A. MINUTA, *Brongt.* Prodrome, p. 155. As there appears to be a good deal of obscurity hanging over this species, M. Brongniart, as far as I can learn, never having

published either description or figure, I give a figure of an *Annularia** from the coal-fields of Western Virginia, to which the name may be applied. The Academy is indebted to Dr. Dixon for it.

GEN. SPHENOPTERIS.

S. PTEROTA, *N. Sp.* Frond bipinnate?; pinnæ nearly linear; pinnules alternate, varying from short triangular and roundish oval to elongate oval, approximate, joined by their decurrent bases, their margins crenulate; the proximal pair with their bases decurrent on the main rachis, which is alate; the medial nerve rather thick and strongly pronounced; the nervules obsolete; stem and also rachis of the pinnules strongly striate.

I have seen but a single small specimen from the coal-fields of Western Virginia; it appears as though the plant was tripinnate, and what I have called the stem was the rachis of a primary pinna. The plant has some affinities with *S. microloba*, Gutb., but is evidently distinct from it.

Museum of the Academy, Dr. Dixon.

GEN. CYCLOPTERIS.

C. FIMBRIATA, *Lesq.*

C. Wilsonii, Wood. Proc. A. N. S., vol. xii, 1860, p. 519.

GEN. ODONTOPTERIS.

O. ROTUNDIFOLIA, *N. Sp.* Pinnæ small, somewhat lanceolate; pinnules small, rather distant, irregularly orbicular, or roundish oval; nervation very indistinct; terminal pinnule irregularly oval, somewhat wedge-shape at the base, lobed on one side near the middle.

Cabinet of the Academy, D. R. Bennett.

O. LESCURII, *N. Sp.* Frond bipinnate?; pinnules alternate, varying from broadly ovate to elongate-ovate, suddenly and very greatly contracted at their base, mostly very obtuse; nervules dichotomously forking, pronounced, rather distant, a number arising from the base, but the central frequently heavier than the rest, and giving off more numerous secondary nervules, so as to present somewhat of the appearance of a midrib; rachis smooth.

The form of the pinnules varies very greatly in this as in all our species of the genus; the upper very small ones are somewhat spatulate, whilst some of the lower are

* Prof. Lesquereux informs me that it is the same species as the plant found by him in the Gates vein, Pottsville, and mentioned by him in his Catalogue under the name of *A. minuta, Br.*

so broad that were it not for their truncate base they would be almost orbicular. All that I have seen are very obtuse, except one broad, short leaflet, which is somewhat acuminate, and occurs on the same stem and close to an elongated, somewhat scythe-shaped, very obtuse pinnule. Some of the larger pinnules were apparently trilobate. The nervation also varies somewhat; in all of them there exist the same, strongly pronounced, rather distant, nearly straight nervules, but in some pinnules the tendency to the formation of a median nerve is much more marked than in the others. The contraction of the base also varies; in some leaflets it is so sudden and angular that the base may be said to be truncate; in these the contraction is generally most marked on the one side, and the part left for attachment is broad; in others, the larger pinnules, this contraction is less abrupt, more regular, and the basal angles are rounded; in such pinnules the attached portion is narrow. I have dedicated this beautiful species to Prof. Lesquereux.

Coal-fields of Western Virginia, Dr. Dixon.

ARTICLE XIII.

SYNOPSIS OF THE CYPRINIDÆ OF PENNSYLVANIA.

BY EDWARD D. COPE.

Read Oct. 19, 1866.

THOUGH the fishes of this family are known to every boy as minnows, shiners, &c., and to the fisherman as his best bait for the capture of the rapacious bass, pike, &c., to the public generally they possess little interest or value. They are nevertheless the most numerous of the vertebrate animal life of our fresh-water streams, both in individuals and species, though to the uneducated eye, the number of the latter would appear far less than is really the case. This is in part occasioned by the general absence of pattern or shade of coloration; the prevailing silver reflections perhaps serve as efficient means of concealment.

The Cyprinidæ attain a great development in the Palæotropical and Palæarctic regions, and occur in the Æthiopian. They exist in numbers but of a smaller and less vigorous growth in the Regio Nearctica, but cease with the northern section of the Neotropical, where their place, as well as that of several other families, appears to be supplied by the more generalized, and as respects their reproductive organs, inferior form of Characinidæ. In the lowest fauna, the R. Australis, the family is also wanting, while Characinoid types people the fresh waters.

The family is associated in North America and Eastern Asia* with a nearly allied form, the Catastomidæ,† and in the Old World, with a second family, the Cobitidæ,‡ which together form the order Euentognathi of Gill. This group was first separated accurately as a family by Agassiz. It is defined as follows:

Inferior pharyngeal bones prolonged upwards into two falciform tooth-bearing vertical jaws; brain-cavity of the cranium prolonged between the orbits; maxillary bones well developed. Fourth ventricle of the brain with a median lobus impar behind the cerebellum.

* Vide Bleeker's discovery of a Carpiodes chinensis in China.

† Characterized by Gill, Proceed. Academy, 1861, 6.

‡ Cobitoidæ and Homalopteroidæ; Gill, Proc. Ac. Phila., p. 6.

The family of the Cyprinidæ is thus defined:

Pharyngeal bones short, with an external ala, supporting a short series of not more than seven teeth, which have cylindric or sub-cylindric shanks. Mouth bounded above by the premaxillary only, not surrounded with fleshy lips. Dorsal fin with an osseous spine.*

My object is to present here a brief outline of characteristics of the species found in the waters of our State, for the benefit of students, since the present state of the literature of the subject renders the study of them very laborious.

Three memoirs comprise most of our knowledge of the subject, viz., two by Prof. Agassiz, in Silliman's Journal, 1854–5, On the Fishes of the Tennessee River, and the Cyprinidæ of the Pacific Slope of North America, and one much more extended by Girard, in Proceedings Acad. Nat. Sciences, Phila., 1856, on the Cyprinidæ of the Mississippi Valley. Prof. Kirtland's Fishes of Ohio (Boston Journ. Nat. Hist.), and Storer's Synopsis of Fishes of North America (Trans. Americ. Academy), are also necessary to a comprehension of the subject.

Our genera as at present understood, are fifteen in number; they express the natural relations of twenty-eight species. These are mostly of small size, and bear so close a resemblance to each other as to be confounded by ordinary observers during the seasons when not in their nuptial dress. Then indeed the brilliancy of their coloring attracts the most indifferent, and they are caught to be admired in aquaria; but they only fade on removal from their native haunts. The gorgeous crimson of the Argyrei, the Chrosomi, and the Clinostomi, are in no wise inferior to the tints of the boasted trout in his brightest array, and the admired gold-fish does not gain by the comparison. A few species attain a moderate size; the Stilbe *americana* and Semotilus *corporalis* occur of two lb. weight, and the Semotilus *rhotheus* rarely reaches four.

The Argyrei, the Chrosomi, and the Clinostomi prefer the clearest and most sparkling rivulets, the home of the trout, whose rapid movements and bright tints they repeat; they occur everywhere, in close parties or little shoals. Some of the Semotili are fish of much vigor of movement, and prefer the rapid waters of the larger creeks; others are less

* The following are the characters given by Prof. Gill (l. c.), for this family:

"The body is oblong or moderately elongated, compressed or sub-cylindrical, and covered with scales of various sizes.

"The barbels vary in number from two to four, and in numerous genera are even entirely absent. The pectoral fins have broad vertical bases inserted in the usual manner on the sides above the breast. They have each a simple ray. The dorsal and anal fins are either with or without spines, which themselves are either simple or dentated. The pharyngeal bones have normally one constant row of normally five teeth, occasionally four, and often one or two supplementary rows of from one to three smaller teeth. The branchial apertures are of moderate size, and separated from each other by an isthmus of little or moderate width."

active, and with the sluggish Exoglossa and Campostomæ, glide in short gyrations in the depths of the clear and quiet pools of our forest streams. The Stilbe and Hypsilepis cornutus, with some Hybopses, do not dread the neighborhood of mankind; they are the denizens of the milldam and race, and are usually the chief ornaments of the "strings" of the urchins, whose wanderings have not attained the river or creek bank. They are equally abundant in the quiet parts of the large rivers, where their dimensions are quite dignified in comparison with the swarming Hypsilepes, Alburnelli, Hybopses, and Hyborhynchi, which prefer the same localities.

These differences of habit are associated with peculiarities of food and of the structure of the digestive system. Few families of vertebrates embrace as great a variety in these respects as the present one. There are carnivorous, insectivorous, and graminivorous genera, which are distinguished as among mammalia, the former by the abbreviation, the last by the elongation, of the alimentary canal; in the former the teeth are usually sharp-edged or hooked, in the latter truncate, hammer, or spoon-shaped. John Jacob Heckel, however, the author who has developed the characters of the Cyprinidæ more than any other, says in reference to this point: "It is known that in general the length of the alimentary canal, as well as the direction of the oral opening, corresponds to the manner of nourishment of the animal, but among our Cyprinidæ this rule has but a narrow application, since the common carp (Cyprinus carpio), whose alimentary canal is only double the length of the whole body, is as completely herbivorous as those East Indian species whose intestines are wound knot-like in a length of eleven times that of the body. On the contrary, the species of Barbus, whose alimentary canal is similar in length to that of Cyprinus, or our Rhodeus, the only European which resembles the Indian species in the length and involution of its intestines, live altogether on animals."

In the American genera, as far as included in the scope of this essay, the peculiarities of the intestines correspond with the food. In the Alburnellus rubrifrons, they are but $\frac{4}{5}$ the length of head and body (excluding caudal fin). In Hypsilepis kentukiensis, Photogenis leucops, Argyreus atronasus and nasutus, Ericymba buccata, and Exoglossum maxillingua, abut $\frac{7}{9}$; the food of the last five species is insects and crustaceans, the last depending largely on mollusca. In the species of Ceratichthys, Semotilus, and Hybopsis, with Hypsilepis cornutus, $\frac{15}{16}$, to equal the length; the habits, insectivorous. The genera with longer intestines are, first, Stilbe $1\frac{2}{5}$ to $1\frac{3}{4}$ the length; Chrosomus, Hyborhynchus, and Pimephales $2\frac{2}{5}$ to $2\frac{2}{3}$, and Hybognathus 4 times. The intestines in these are generally filled with a soft dark-colored slime, without remains of insects, but of vegetable origin. In the remarkable genus Campostoma the canal extends to between eight and nine times the length, and, like that of other vegetable-feeders, is usually found occupied by the ingesta for a considerable part of its length. The European genera most

nearly allied, Chondrostoma and Rhodeus, possess intestinal canals 2.66 and 3.5 times the length of the body respectively.

The alimentary canal in the Cyprinidæ offers no distinction into stomach and small and large intestine; its anterior portion is generally of greater diameter than that succeeding. The principle of its arrangement is that of a sigmoid with the three limbs appressed and in contact. In those genera with short intestines, the proximal flexure is anterior to the hinder extremity of the abdominal cavity, the distal, behind the anterior, thus reducing the median tract. Length is gained by extending the proximal flexure to near the vent and the anterior to near the head; while the additional complications of more vegetable-feeders take place first about the distal or anterior flexure, where portions of the middle and distal tracts may be together several times laterally folded, or new flexures may be added in the middle and distal tracts themselves. By the last mode, accommodation for the greatest extent is procured. In any case the proximal tract is not flexed, evidently that it may serve as a receptacle for the objects taken as food. The liver is attached to two, or sometimes three tracts, in a band or bands between them.

The Cyprinidæ of the Eastern district of North America appear to be referable to four tribes, as follows:

Dentary bones straight and flat, united together throughout their length; natatory bladder lying along the vertebral column, above the alimentary canal; opercular and mandibular bones not cavernous. COCHLOBORI.

Dentary bones slender, arched, and widely separated, except at their symphysis; natatory bladder lying along the vertebral column, and above the alimentary canal; opercular and mandibular bones with external cavernous chambers. CŒLOPHORI.

Dentary bones slender, arched, widely separated, except at their symphysis; natatory bladder lying along the vertebral column, and above the alimentary canal; opercular and mandibular bones without external cavernous chambers. EPICYSTI.

Dentary bones slender, arched, widely separated, except at their symphysis; natatory bladder suspended in the centre of the abdominal cavity by numerous convolutions of the alimentary canal which surround it; opercular and mandibular bones without external cavernous chambers. MESOCYSTI.

The genera are as follows:

Tribe I. COCHLOBORI.

Barbels none. Premaxillaries not projectile; skin of lip and front continuous. Teeth 1, 4—4, 1 or 2, hooked, without masticatory surface. Dorsal fin above ventrals; anal basis short. Mouth inferior; mandible much contracted, with lobe on each side of base. EXOGLOSSUM.

Tribe II. CŒLOPHORI.

Dorsal fin above ventrals; basis of anal short; teeth hooked, without masticatory surface, 1, 4—4, 0; mouth subinferior, small; scales moderate; lips normal. ERICYMBA.

Tribe III. EPICYSTI.

Group I. Maxilla with barbels; pharyngeal teeth hooked, without masticatory surface; bony dorsal ray attached; alimentary canal shorter than to equal length of head and body (without caudal fin).

a. Premaxillaries projectile; lip separated by a dermal fold.

No terminal; two lateral maxillary barbels; teeth 2, 5—4, 2. SEMOTILUS.

Two terminal, no lateral maxillary barbels; teeth 3, 5—5, 2. GOBIO.

Two terminal, no lateral maxillary barbels; teeth 2, 4—4, 2, or the front row 1–1 or 0–0. CERATICHTHYS.

aa. Premaxillaries not projectile; skin of lip and front continuous.

Two terminal, no lateral maxillary barbels; teeth 2, 4—4, 2; isthmus wide. ARGYREUS.

Group II. No barbels; pharyngeal bones hooked, with or without masticatory surface; first (osseous) dorsal ray adherent.

a. Teeth of inner pharyngeal series 5–4 or 5–5 (two-rowed).

Dorsal fin above ventrals; teeth inner row 5–5, no masticatory surface; mouth terminal; scales usual surface exposed. (SQUALIUS.)

Dorsal fin above ventrals; teeth, inner row 5–4, without masticatory surface; mouth inferior; scales usual surface exposed. (TELESTES.)

Dorsal fin markedly behind ventrals; anal, basis elongate; teeth, inner row 5–5 without masticatory surface; mouth superior; scales usual surface exposed. (ALBURNUS.)

Dorsal fin over space between ventrals and anal; anal, basis elongate; teeth one-rowed, with masticatory surface, and crenate; usual surface scales exposed; mouth oblique; alimentary canal elongate. STILBE.

Dorsal fin behind ventrals; anal, basis short; teeth one-rowed, 5–5, 4–5, with masticatory surface; mouth straight or oblique; scales small, normal, lateral line interrupted or wanting; alimentary canal elongate. CHROSOMUS.

Dorsal fin behind ventrals; anal, basis short; teeth two-rowed, inner, 5–4, without masticatory surface; mouth oblique; scales minute, exposed as usual; lateral line interrupted or incomplete; alimentary canal short. PHOXINUS.

Dorsal fin little behind ventrals; anal short; pharyngeal teeth two-rowed, without masticatory surface, inner series 5–4; mouth large, oblique; scales usual surface exposed; lateral line complete. CLINOSTOMUS.

aa. Teeth of inner pharyngeal series 4–4 (often one-rowed). Alimentary canal not longer than head and body.

Dorsal fin over space between ventrals and anal; anal basis sometimes elongate; teeth two-rowed, not crenate, rarely with narrow masticatory surface; scales normal. ALBURNELLUS.

Dorsal fin over ventrals; anal, basis short; teeth two-rowed, without masticatory surface, smooth; scales normal; mouth oblique. PHOTOGENIS.

Dorsal fin over or a little behind ventrals; anal, basis short; teeth two-rowed, with masticatory surface, and sometimes slightly crenate; exposed portion of scales much narrowed, hence elevated; mouth oblique. HYPSILEPIS.

Dorsal fin over ventrals; anal, basis short; teeth one or two-rowed, with masticatory surface, smooth; scales large, normal; mouth small, inferior. HYBOPSIS.

GROUP III. No barbels; pharyngeal teeth sharp, hooked; alimentary canal shorter than body; dorsal fin with a strong elevated spine.

Teeth 1, 4—4, 1; body scaleless. MEDA.

GROUP IV. No barbels; pharyngeal teeth 4–4 only, cultriform, *i. e.*, with oblique masticatory surface, with no hook. First (bony) dorsal ray adherent to first articulated; labia attenuated; intestinal canal four times length. Labia without sheath; dorsal fin above ventrals; teeth one-rowed. HYBOGNATHUS.

GROUP V. No barbels; pharyngeal teeth one-rowed, 4–4, with masticatory surface, sometimes hooked; osseous dorsal ray separated from first articulated, by membrane; intestinal canal between two and three times length of head and body.

Lateral line continuous; head broad; mouth small, subinferior. HYBORHYNCHUS.

Lateral line incomplete; head short, elevated; mouth small, inferior. PIMEPHALES.

TRIBE IV. MESOCYSTI.

No barbels; pharyngeal teeth usually 4–4 only, with oblique masticatory surface and no hook; first (osseous) dorsal ray attached; labia with attenuated cartilaginous sheath; mouth inferior; alimentary canal six to nine times length head and body. CAMPOSTOMA.

Of the above, the species of Semotilus, Ceratichthys, Hypsilepis, Clinostomus, Campostoma, Hyborhynchus, and Pimephales, develop in the male sex, during the breeding season, rows of spinous tubercles on the head; while the body is adorned with bright tints of red in Argyreus, Clinostomus, Chrosomus.

The following is the distribution of the species with reference to our three great water basins, so far as known:

OHIO.	SUSQUEHANNA.	DELAWARE.
	Semotilus rhotheus.	Semotilus rhotheus.
Semotilus corporalis.	Semotilus corporalis.	*Semotilus corporalis.*
	Ceratichthys micropogon.	
Ceratichthys biguttatus.	Ceratichthys biguttatus.	
Ceratichthys dissimilis.		
Argyreus atronasus.	Argyreus atronasus.	Argyreus atronasus.
	Argyreus nasutus.	Argyreus nasutus.
Stilbe americana.	Stilbe americana.	Stilbe americana.
Hypsilepis cornutus.	Hypsilepis cornutus.	Hypsilepis cornutus.

Ohio.	Susquehanna.	Delaware.
Hypsilepis Kentukiensis.	Hypsilepis Kentukiensis.	Hypsilepis Kentukiensis.
Hypsilepis diplaemia.		
Clinostomus proriger.		
Clinostomus elongatum.	Clinostomus funduloides.	Clinostomus funduloides
	Clinostomus margarita.	
Photogenis leucops.		
		Hybopsis chalybaeus.
	Hybopsis procne.	Hybopsis procne.
		Hybopsis bifrenatus.
	Hybopsis hudsonius.	Hybopsis hudsonius.
Alburnellus rubrifrons.		
Chrosomus erythrogaster.	Chrosomus eos.	
Hyborhynchus notatus.		
Campostoma dubium.		
Ericymba buccata.		
	Exoglossum maxillingua.	

The species inhabiting waters flowing into Lake Erie, are not determined. Among many occurring in the Ohio list above, may be selected with certainty Stilbe americana, Hypsilepis cornutus, and Hyborhynchus notatus; add Hybopsis storerianus and H. hudsonius.

It appears then that five species are common to all three river basins; that one species occurs in the Ohio and Susquehanna that is not found in the Delaware, and five species in the Delaware and Susquehanna, not occurring in the Ohio. Species as yet peculiar to the Ohio, ten; peculiar to the Susquehanna, four; peculiar to the Delaware, two. These figures will be more or less changed by future investigations.

In examining the pharyngeal teeth of the smaller Cyprinidæ, the student must be careful to observe the character of the masticatory surface. A lateral bevel of the edge of the tooth, sometimes somewhat obliquely turned, has much the appearance of such a surface to the unpractised eye; it however leaves the cutting edge of the tooth clearly marked. On the other hand, the masticatory surface constitutes a complete and usually broad truncation throughout the length of the portion, otherwise occupied by the edge. In young individuals of many genera, the edges of the teeth are serrate. This is persistent in the adults of the genus Stilbe, and of some species of Hypsilepis; in Europe it characterizes Scardinius.

It may be premised, that in the following descriptions the scales are counted from the origin of the first dorsal ray, to that of the ventral, never including those of the vertebral series.

The peculiarities of the Cyprinoid fauna of the Eastern district of North America, *i. e.*, from the Atlantic Ocean to the base of the Rocky Mountains, as compared with the Palæ-

arctic are, firstly, the existence of the three tribes Cochlobori, Cœlophori, and Mesocysti; as far as known the genera of the latter region, as well as those of the Palæotropical, are all referable to the tribe Epicysti.

As regards the Epicysti we observe, first, the absence of types related to the true Cyprinus, or to Barbus, the most bulky species of the family, as well as the smaller size in general of the American species, whether representative or peculiar; third, the abundant representation of the few species of Gobio and Bungia; fourth, the abundance of forms closely resembling the genera Squalius and Idus; fifth, abundance of forms intermediate between Cyprinidæ with soft lips, and those with cartilaginous labial sheaths; sixth, the paucity of representatives of Abramis, and over the Eastern part of the area, of Alburnus.

While, then, many of the genera of this district may be said to represent those of Europe, such appear to be separated by one prevalent ground of distinction, viz., the smaller number of teeth than in the European types. The inner series is commonly 6–5 or 5–5, sometimes 4–5 in the genera of the Old World;* in our Eastern district two genera rise to 5–5 and two to 4–5, while all the others possess 4–4, and many but a single row, which is unusual among European genera. In the Pacific region, the genera of Cyprinidæ, as of many other animals, repeat the European structure and bulk more nearly. In the following table the European genera are in italics; the representatives are opposite:

Inner series 5–5.	5–4.	4–4.
Gobio.	Semotilus.	Ceratichthys.
Bungia.		Argyreus.
Stilbe.		Platygobio.
Abramis.		
Blicca.		
Bliccopsis.		
Pelecus.		
Alburnus.	*Alburnus.*	Alburnellus.
		Photogenis.
Aspius.	Clinostomus.	
Leucaspius.		
Idus.		
Scardinius.		Cyprinella.
Leuciscus.		Hypsilepis.
Squalius.	*Telestes.*	Hybopsis.
		Codoma.
		Cochlognathus.
		Meda.
	Phoxinus.	

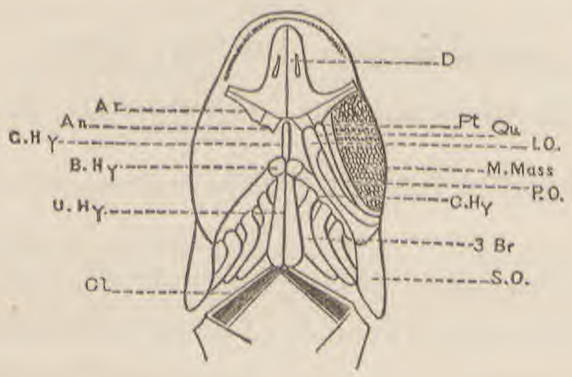
* Phoxinus is rarely abnormally 4–4. Girard gives 5–5 in Semotilus, but I have not yet observed it.

Inner series 5–5.	5–4.	4–4.
	Phoxinus.	
Chrosomus.	Chrosomus.	
		Hybognathus.
		Hyborhynchus.
		Pimephales.
Chondrostoma.		Campostoma.

EXOGLOSSUM, *Rafinesque.*

Journ. Acad. Nat. Sci., Phila., I, 1818, 420.

D. Os dentale.
Ar. Articulare.
An. Angulare.
Pt. Pterygoideum.
Qu. Quadratum.
I. O. Interoperculare.
P. O. Præoperculare.
S. O. Suboperculare.



G. Hy. Os glossohyoideum.
B. Hy. Basihyoideum.
C. Hy. Ceratohyoideum.
U. Hy. Urohyoideum.
3 *Br.* Rad. Branchiostegi.
Cl. Claviculus.
M. Mass. Musc. Masseter.

This genus was first properly defined by Professor Agassiz in his excellent review of the genera of American Cyprinidæ, in 1855, though he only explained the singular arrangement of the dentary bones by calling it "a projection of the symphysis of the branches" of the jaw, nor regarded its peculiarity as of so much weight as here indicated. Hence he placed it as affined to Campostoma. Girard, in his more extensive review (1856), correctly denies this relationship, and places it among the more ordinary types,—as Alburnus, &c. This approximation appears to me as erroneous as the last; in nature it has much of the manners of the Campostomæ, but not their habits, and the structure of the mandibular arch has no parallel among either series. I have therefore established for it a distinct tribe.

The series of pharyngeal teeth is situated chiefly on the inferior limb of the bone, the lower tooth being on a line with the angle of the lateral ala. The arched bones themselves are unusually small, and situated more within the scapular arch than in other genera.

The mandible is not margined by lips, nor covered with a cartilaginous sheath; the basal lobes are the rudiment of the former. The incompletely defined body which in this family represents the tongue is situated in the back part of the oral cavity, since the glossohyal bone is excluded from its usual place, and is short; its approximation to the intro-

percle and ceratohyal, with the basihyal and strong elongate urohyal, defend the lower surface of the head effectually.

This structure is obviously associated with the habits of the animal. The stomach usually contains abundant remains of Physæ, Pisidia, and other small mollusca, which form its food. The shovel-like mandible would appear to be adapted for removing these creatures from their hold on the rocks and bottom, while the great strength of the pharyngeal walls and muscles enables the fish to crush the shells before mastication with the pharyngeal teeth.

Besides the below-mentioned, Girard describes a species from Texas.

EXOGLOSSUM MAXILLINGUA, *Leseur.*



Cyprinus maxillingua, Leseur, Proc. Acad. Nat. Sciences, Phila., 1817, 85. *Exoglossum*, do., Haldeman, Rupp, Hist. Lancaster Co., Pa., 1844, 474, Agass., *l. c.*, Girard, *l. c.*

Eye on the frontal plane, opening longitudinally oval, longest diameter $4\frac{1}{3}$ times in head, one and a half times in muzzle. A bony prominence at angle of preopercle and base of mandible; latter withdrawn into mouth when closed. Mouth slightly oblique, end maxilla not attaining line of orbit. Operculum higher than broad, convex below; the sub-operculum sickle-shaped, incurved; top of cranium broad, plane between nares; muzzle suddenly descending; interorbital breadth equal from end of mandible to margin of preopercle; scales, exposed portion higher than wide, radial grooves very numerous, and with the concentric ridges strong; 10–49–5; lateral line deflexed in front, median behind middle of dorsal fin. Head five times in total length or four and a quarter to base caudal; greatest depth five times to base of caudal. Caudal peduncle, depth $1\frac{3}{4}$ of greatest length. Back broad anteriorly, compressed at base of dorsal fin. Pectoral fin $\frac{2}{3}$ length to ventrals; latter to vent; basis of anal less than that of dorsal; height of anal $\frac{1}{4}$th more than basis of dorsal, equal height of dorsal; outlines of both straight. Emargination of caudal, one-third its length.

Length of a fully grown individual 5.75 inches; end muzzle to first dorsal ray 2.57; same to origin caudal 2.44; first anal to same point 1.5; breadth between præopercula below .75. Color olivaceous, smoky above; a blackish band from pectoral fin to superior extremity of gill opening.

This fish is abundant in all the tributaries of the Susquehanna which have been examined, and is not known from other waters. In its movements it is sluggish; it keeps near the bottom in pools and channels of our clear rocky streams, not preferring rapids. It takes the hook very readily.

ERICYMBA, *Cope.*

Proceedings Acad. Nat. Sciences, Phila., 1865, 87.

This form appears to be related in structure to allied genera of the Cyprinidæ, as

Acerina is to some others among Percidæ. Its general appearance is that of a small Gobio or a Hybopsis, with the muzzle rather heavier than is usual in either; but examination shows that, besides the absence of barbels, it is peculiar in that the suborbital and interopercular bones, with the rami of the mandible, are greatly dilated, and bear septary laminæ, which separate mucus cavities, relatively as large as those of Acerina or Percopsis. They extend in two series; seven from the postorbital bone to the side of the end of the muzzle, and eight from the same point to the symphysis mandibuli. The muzzle overlaps the mandible; no cartilage on the latter. Scales large, the usual surface exposed. Anal short, originating opposite end of depressed dorsal. Origin of ventrals opposite first dorsal ray. Pharyngeal bones slender; teeth acutely uncinate-raptatory, without masticatory surface, 1.4—4.0.

I am not aware that any genus of Cyprinidæ exists in the Old World which possesses the cavernous structure above mentioned. Traces of it may be observed on the interoperculum in certain genera, *e. g.*, Hypsilepis.

The tooth series is situated entirely below opposite the alar angle of the pharyngeal bones, as in Exoglossum; in other genera the angle falls opposite the middle of the series. The length of the alimentary canal is less than that of head and body, and the natatory bladder extends throughout the whole length of the abdominal cavity.

ERICYMBA BUCCATA, *Cope*, loc. cit., Supr.



The subopercular is small; operculum height to breadth as one and one-half to one. Head broad, muzzle obtusely rounded. Canthus of mouth opposite nares. Length of head contained three and five-sixths times to origin of caudal; greatest depth (at dorsal) nearly five times in the same. Caudal peduncle elongate, not constricted. Eye large, contained a little more than three times in length of head, a little more than frontal width. Origin of dorsal a little in advance of the point midway between end of muzzle and origin of caudal, its anterior ray equals half the distance from its base to anterior nostril. Caudal furcate one-half its length. Ventrals barely reaching vent; pectorals attaining ventrals. Scales $\frac{5}{3}$ 33; exposed portion with very numerous and delicate radii and concentric lines, not visible to the naked eye. A narrow space from vent to opposite middle of pectorals scaleless. Fins, DI. 8. C.+17+. A. I. 8. V. 8. P. 12. Lateral line nearly straight. Along and above it is a lateral band of brown punctulations; general color above yellowish olive, the edges of the scales dark-shaded, and a narrow brown vertebral line from nape to tail. Below lateral line silvery. Dorsal and caudal fins rosy. Length of a half-grown specimen, from muzzle to opercular edge 7 l.; to dorsal fin 13 l.; to end of appressed anal 1 in. 9 l.; to origin of caudal 2 in. 2 l.; to end of caudal 2 in. 8 l.

This species was originally known only from the Kiskiminitas, but Dr. Stimpson has taken it in abundance in the Muskingum, and William P. Clark, in the White River, Indiana, thus indicating an extensive distribution.

SEMOTILUS, *Rafinesque.*

Leucosomus, Heckel and Girard.

This genus, with Ceratichthys, represents the European Gobio; fifteen species of the two former, with two of Platygobio, Gill, take the place in North America of the two known of the latter. The above synonyme was the result of an overlooking of the barbels, which are sometimes quite obscure. None of the species have the muzzle depressed or the mouth inferior as in the previous genus; this with the head, is obtuse and massive; the general form is deeper. The scales are large and present strong radii. Length of intestinal canal nearly equal that of head and body.

Lateral line originating below upper angle of operculum; scales large 45–7 in lateral line. RHOTHEUS.

Lateral line origin at superior angle of operculum; scales smaller; l. l. 57–9; black spot at base of dorsal fin; eye 5 to 5½ times in head. CORPORALIS.

Lateral line origin at superior margin operculum, scales smallest 9—63-5—7; elongate, muzzle long, eye one-sixth head; dark spot at base dorsal, no dark on sides, head, or body. PALLIDUS.

SEMOTILUS RHOTHEUS, *Cope.*



Proc. Acad. Phila., 1861, 564, *S. corporalis*, Abbott, do. 1861, 154 (not *Cyprinus corporalis*, Mitchell). *Squalius hyalope*, Cope, *ibid.* 1864, 280.

This species and the next have a very broad preorbital bone, and the eye nearer the end of the muzzle than the opercular border. The posterior end of the margin of the operculum is above opposite the inferior margin of the orbit in both.

The S. rhotheus is the largest of our Cyprinidæ, reaching a length of eighteen inches. The dorsal line is arched and is continuous with the rather steep slope of the cranium to the labial border. Scales 8—45-7—5, a nearly equal portion exposed on the anterior and posterior parts of the body. The dermal sacs which hold them are black-margined, and extend beyond the tip of the preceding scale. Fins D I. 8. P. 17. V. 8 A. 8 C. 18. The head is broad, frontal width equalling one-half of superior length, muzzle rather short; the eye enters nearly twice into length of latter, and five times into that of the head. The head is one-fourth the length to the base of the caudal.

The colors of this species are particularly brilliant, having as ground a very pure silver white. The dorsal region is often steel-blue and the preopercular and subocular regions

bright roseate. In spring and summer adult males have longitudinal rosy lateral shades, and the dorsal and pectoral fins are crimson.

This chub is a most active and vigorous fish, and haunts especially rapids and falls,—the large individuals in the rivers and the smaller ones in the creeks and runs. It takes the hook without much play, and is good food, though not highly esteemed. When taken from the water it utters a chirruping and croaking noise, more like a voice than any sound heard from any other fresh-water fish of our region. Its food consists largely of "apple smellers," *Gyrinidæ*. Its common name in Pennsylvania is "fall fish."

Its habitat is the waters of the Susquehanna, Delaware, and other basins eastward to Massachusetts, where it is not common. It is much more abundant in Delaware than Susquehanna waters.

This species was first described by Abbott, who gives an account of the coloration of the male in spring. He identified it with the *corporalis* of Mitchell; the description of that species however applies equally well to the following, and the fact of its being stated to occur in river water (at Albany), and its western distribution, would refer it to the same. This view has been also taken by Putnam, who has published the synonymy given below, but was apparently not acquainted with the S. rhotheus.

Specimens of both rhotheus and corporalis of 2.5 inches and less in length do not possess barbels in many instances which have come under my notice; in such a condition they are not distinguishable on the usual basis, from the genus Squalius. Such a specimen I referred on a former occasion to that genus, along with others, which I am now able to separate.

SEMOTILUS CORPORALIS, *Mitchell.*

Cyprinus, Mitchell, American Monthly Magazine, ii, 324, and *C. atromaculatus*, Ibidem. *Semotilus dorsalis* et *cephalus*, Rafinesque, Ichthyologia Ohiensis. *Leuciscus Storeri* and *iris*, Cuv. Val.



This species is well distinguished from the last, as given in the table, as well as in the adult, by the narrowness of the exposed portion of the scales anteriorly as compared with that posteriorly, by the dark spot at the base of the dorsal fin, and darker colors above, in part caused by the exposure of the dark edges of the scale sacs. The pharyngeal teeth are shorter, and occupy a shorter basis on the bone.

Dorsal outline arched, descending steeply to labial margin; eye little less than one-fifth length of head; interorbital breadth one and three-fourths in length above. The relative width of the head differs slightly, some speci-

mens being more clumsy than the above; its length $3\frac{3}{4}$ in. total to origin caudal. Scales 9—47-9—6, DI. 7. P 17. V 8. A. 8., thirty on vertebral line in front of dorsal fin. Above blackish, scales above lateral line paler in the centre; below cream-colored; cheeks and opercle silver orange, a dark shade through eye. Dorsal fin in old males, red orange basally, except an anterior black spot. Length to end of caudal 9 in.; to base of do. 7 in. 8.5 lin.; to base of dorsal 4 in. 1.5 lin.; do. of ventral 4 in.

This species has not the vigor and beauty of the last, but is perhaps more active than the Ceratichthys biguttatus. It swarms in the smaller tributaries of the Susquehanna, where it continually takes the bait of the fisher for more valuable prey. As an article of food it is ordinary, but not to be rejected. It is less abundant in the Kiskiminitas, and Youghiogheny, tributaries of the Ohio, though not at all uncommon; nor is it more plentiful in the streams of the Delaware; outside the State, its distribution east of the Hudson is not known; it is characteristic of all the northern tributaries of the Mississippi to the upper waters of the Platte, and is common in the tributaries of the great Lakes. A diagnosis of the allied S. pallidus, Girard, from the Platte River, is introduced for comparison.

The Semotilus corporalis is known in Pennsylvania as the "Chub." Putnam first gave (in Bulletin Mus. Comp. Zool., Cambridge), its synonymy in full, which is entirely confirmed by my examinations of large series of specimens. The frontal and parietal width is greater in some specimens than others, and even in the relative length of the head to the body there is slight variation. In some young specimens there are no dark edges to the scale sacs, and occasionally (*e. g. ex.* from White River, Ia., *W. P. Clark*), the scales are nearly as much exposed anteriorly as posteriorly.

It is represented northeastwardly by the Semotilus argenteus (*Leucosomus pulchellus*, Gird.)

CERATICHTHYS, *Baird, Girard.*

? Hybopsis, Girard, Pt. Proc. Acad., Phila., 1856, 210. Girard, *l. c.*, 1856, 212. *Nocomis*, Girard, *l. c.*, 190.

This extensive genus embraces considerable variety of form and character, but forms an unbroken series from one extreme to the other. Indeed it cannot be said to be more heterogeneous than our present knowledge indicates to be the case with natural genera of much extent. The three subtypes are characterized in the table below; of these the third cannot be regarded as generically distinct from the second, as the first section unites in itself prominent features of the two.

In adults of the C. cyclotis m. (the Northwestern obtuse-headed representative of the C. biguttatus), the teeth are normally either 1.4—4.0 or 1.4—4.1; in half-grown specimens (eye one-fourth head) nearly always 1.4—4.1; in young specimens (eye 3.5, in head) always 1.4—4.1; in the last stage they resemble very much certain Hybopses as

H. hæmaturus, where the form of the mouth and the squamation are about the same; the dentition is an infallible distinction. I have examined large numbers of individuals of both, from various parts of Michigan and Indiana.

Several species not yet detected in our State are introduced for comparison. Our species are distributed as follows:

A. micropogon,	. . .	Susquehanna.
A. biguttatus,	. . .	Ohio, Lake, and Susquehanna.
A. dissimilis,	. . .	Ohio.

I. Mouth terminal; teeth 4.0--0.4 or 4.1—1.4; scales larger, radii stronger; isthmus medium.

Head short convex, end maxillary opposite eye, which enters length head $3\frac{1}{4}$ times; caudal peduncle slender; yellowish, a dark lateral and median dorsal band. MICROPOGON.

Head elongate, with muzzle slightly projecting, $4\frac{1}{2}$ times in length; outline arched from end muzzle, depth equal head; scales $\frac{7}{6}$ 40; teeth 1.4—4.1; dark band on muzzle and spot at base of tail. STIGMATICUS.*

Head obtuse, dorsal outline flat; height $4\frac{2}{5}$ length; lateral line nearly straight; eye $5\frac{1}{2}$ times in head; scales $\frac{7}{5}$ 41; teeth 1.4—4.1 or 0; caudal peduncle thick; olive above, yellowish below; operculum rounded above. CYCLOTIS.†

Head elongate, acuminate, dorsal outline flat, depth $4\frac{3}{4}$ length, eye 5—$5\frac{1}{2}$ times in head; caudal peduncle short; scales $\frac{6}{4}$ 40; teeth 4—4; operculum angulated above. BIGUTTATUS.

II. Mouth slightly inferior; teeth 0.4—4.0; scales larger; radii stronger; isthmus medium.

Slender, eye large, head one-fifth length; scales l. l. 49; dorsal fin larger than anal; a lead-blue lateral band. DISSIMILIS.

Slender, eye large, twice in length of muzzle; head one-fourth length; scales l. l. 70, dorsal smaller than anal. CATARACTÆ.‡

III. Mouth terminal, small; teeth 2.4—4.2; scales larger, concentric lines stronger; isthmus narrow.

Head one-fifth total length, depth body equal; eye one-fourth length of head; muzzle obtuse; scales 10-12—61-5—7-9; head and above blackish, a plumbeous band above lateral line, white below. PROSTHEMIUS.§

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* *Ceratichthys stigmaticus*, Cope, Proc. A. N. Sci., Phila., 1864, 278, from Michigan.

† *Ceratichthys cyclotis*, Cope, *l. c.*, p. 278, from Michigan and Kansas.

‡ *Gobio cataractæ*, Cuv. Val., from Niagara. The pharyngeal teeth of this species are not described, but the inference from C. V., is that they are more as in Gobio.

§ Ceratichthys prosthemius, m. sp. nov.



This is a fish of the average size of Semotilus corporalis, but much more slender form; the outline is fusiform, the head being small and the muzzle broad and abruptly descending. Back compressed medially, first dorsal ray medial between end muzzle and origin caudal, considerably longer than first anal, its base longer than base of anal, ventrals opposite first dorsal ray, not reaching vent. End of maxillary not extending to opposite orbit; nares equally distant from each other and premaxillary margin.

The alimentary canal in the above species is nearly as long or as long as the head and body.

CERATICHTHYS MICROPOGON, *Cope*.

Proc. Acad., Phila., 1864, 277.



The appearance of the head of this fish is that of a Hypsilepis rather than of a chub, and the difficulty of discerning the minute barbels increases the liability to err in determining its affinities.

Mouth slightly oblique; angle opposite anterior border of orbit. Latter enters 3¼ times in length of head, which is measured 3¾ times in length from muzzle to base of tail. The greatest depth is measured 4¼ times in the same distance. Head broad, muzzle obtuse, profile rounded descending. Caudal peduncle long. Scales as in C. biguttatus, $\frac{6}{3}$ 40. Teeth 4—4, without masticatory surface, the posterior considerably hooked. Length, from origin of tail to anterior base of dorsal equal from dorsal to posterior nostril. Rays, D. 1.8; C. 19; A. 1.7; V. 8; P. 13. Above pale yellowish-brown, with brown vertebral band; a broad brown shade from end of muzzle to base of tail; below pale yellowish. Length, 3 in. 6 lin.

Renewed examination confirms the normal distinctness of this singular fish. Were we disposed to adopt the hybridization hypothesis of Von Siebold, this species might be ascribed to the parentage of Ceratichthys biguttatus and Hypsilepis cornutus. On this question there are, however, no affirmative evidences extant.

I only know this species from a specimen sent me by my friend, Jacob Stauffer, of Lancaster. He took it in the Conestoga, a tributary of the Susquehanna. Whether it occurs in any of the other hydrographic basins is not yet known.

CERATICHTHYS BIGUTTATUS, *Kirtland*.

Boston Journ. Nat. Hist., iii, 1840, 344. *Ceratichthys*, Baird, Girard, Proc. Acad. Phila., 1856, 213.

The largest specimen of this species before me measures six and a half inches long.

Habitat. Lake Superior; specimens from the Montreal River, Keweenaw Pt., Lake Superior, from a fine collection made for the Academy, by our member, Dr. J. H. Slack. This species is quite peculiar in physiognomy in the genus. The Gobio plumbeus, Agass., has a much shorter head (one-fourth length) and smaller eye, and resembles more the Semotilus type. The stomach was filled with homopterous insects.



This is a stout species with a deep, compressed caudal peduncle, and large scales, of which an equal portion is exposed on the anterior and posterior parts of the body; number 6—40—4. The lateral line originates in a line with the superior margin of the operculum. Dorsal outline straight to above the nares, then the steep slope of the muzzle; the view of the orbit coincides with the plane of the vertex and is its own diameter above the horizontal line from the inferior posterior angle of the operculum. The eye is nearly equidistant between the end of the muzzle and the posterior margin of the operculum, giving it a physiognomy markedly different from that of the S. corporalis and rhotheus, and connected with an elongate parallelogramic form of the preopercular bone, D. I. 8. P. 15. V. 8. A. 7. C. 19. The head enters three and three-fourths times into the length to the origin of the caudal.

The general tint of this fish is brownish cream-colored, shaded with slate above the lateral line, where the scales are tipped and margined with the same. A dark postopercular crescent; operculum golden, with slate shades.

This fish abounds in all the streams in the State, except those emptying into the Delaware, in which I have never seen it. It is called the horned chub, from the numerous spinous tubercles which cover the vertex and muzzle in the breeding season; the nose of the males becomes at this time very much enlarged and convex, reminding one of the form of the profile of the Antelope saega, or of the Abyssinian sheep. In its movements there is but little activity, and it prefers pools and rock-shaded holes between the rapids of our mountain creeks. It is especially numerous in the streams tributary to the Ohio and the Lakes. It is not usually used as bait, as the fry only occur in the smaller streams, and the adult are of too large size.

CERATICHTHYS DISSIMILIS, *Kirtland.*

Leuciscus dissimilis, Kirtl., Journ. Boston Soc. Nat. Hist. *Ceratichthys*, Cope, Proceed. Phila. Acad., 1864, 277.



The smallest and most slender species of the genus, near the form of Gobio uranoscopus of Europe. Eye margining the frontal plane, entering three and one-fifth times into length of head, and about one-quarter greater than interorbital breadth.

Length of head four and three-fifths times to concavity of caudal. Pectorals falcate, not reaching ventrals; latter falling short of vent. Anal with short base; front and inferior outlines equal. Caudal deeply furcate, with acute lobes. Upper outline of dorsal very oblique, longer than anterior. End of muzzle projecting beyond premaxillary border; end of maxillary beyond half way to edge of orbit. Scales 6—49—9, with 8 and 9 strong radii on the exposed surface. Greatest depth five and two-thirds times into length to notch of caudal. Rays D. I. 8. C. 20. A. 7. V. 8.

In coloration this pretty fish rather resembles a Hybopsis, or more the Gobio fluviatilis. It is generally silvery, with a broad plumbeous blue band following the lateral line, which is irregularly deeper and paler in some smaller specimens. A blackish band from end muzzle to orbit.

This is one of the species of "minnows" which are used by the fishermen as bait for Bass (Micropterus) and Catfish. It is a river species and has not the vivacity of the Argyrei. I have seen it from the Monongahela and Youghiogheny Rivers; it occurs also in the Mahoning, according to Prof. Kirtland. It is not found in any of the other water basins of the State.

ARGYREUS, *Heckel.*

Fische Syriens, 1842, 50, Girard, Proc. Acad. N. S., Phila., 1856, 185. *Rhinichthys*, Agassiz, Amer. Journ. Sci. Arts, 1854, 357.

This genus only differs from the last in the non-projectility of the premaxillary apparatus, and the non-continuance of the postmaxillary dermal fold over the muzzle. Alimentary canal rather shorter than length of head and body. So far as known the species are of smaller size than the preceding, and have smaller scales; they are adorned with brilliant hues during the spring and summer, to a far greater extent. In Europe, the Gobio uranoscopus, Agass., has a physiognomy slightly like some of the Argyrei.

Mouth entirely inferior; teeth 2.4—4.2; scales smaller, concentric, lines stronger; isthmus wide; pectoral fins inferior, horizontal, not capable of application vertically to the sides. Head 4½ times in total length. Eye one-fifth length of head; muzzle elongate, narrowed; twelve rows of scales on caudal peduncle. No black lateral band. NASUTUS.

Head four times in total length; muzzle broad, short; eye less than four times in head's length; 8—10 rows of scales on caudal peduncle; a black lateral band; scales l. l. ATRONASUS.

ARGYREUS ATRONASUS, *Mitchell.*

Heckel Fische Syriens, 1842, Girard, Proc. A. N. S., Phila., 1856. *Rhinichthys atronasus*, Agassiz, Am. Journ. Sci. Arts, 1854.

The smaller of our species. As in the nasutus, there are about twenty longitudinal rows of scales between the dorsal and ventral fins. In summer and autumn it is brownish olive above a black band which extends round the nose to the origin of the caudal fin on each side, and satin-white below it. In spring the latter region becomes vermilion red, and the lateral band assumes an orange hue; the pectoral and ventral fins become similar to the abdomen, and the rays of the former are greatly thickened. The brilliant coloring

matter, as has been shown by Prof. Peters, is deposited in little sacs of the derm (chromatophoræ); these may be made to disclose their crimson contents by means of a sharp instrument, some time after the fish appears to have lost his livery. The strengthening of the pectoral rays is appropriate to the increased exertion incident to the impregnation of the eggs. Later in the season the brilliant crimson gives place to orange, which fades to golden; this may often be seen in specimens caught as late as the end of summer, when many have resumed their silver white.

This species is abundant in the rivulets tributary to the three great rivers that drain our State. A Northwestern representative, the R. lunatus, will perhaps be found also within our limits.

Argyreus atronasus is a favorite for aquaria, and is generally sold as the "black-nosed dace."

ARGYREUS NASUTUS, *Ayres.*

Boston Journ. Nat. Hist., Girard. Proc. Acad., Phila., l. c., 1856.
Rhinichthys, Agassiz. *Chondrostoma*, Heckel, Fische Syriens.



This is a larger and more elongate species than the last, with a most prominent and flattened muzzle.

It is of a general olivaceous color, paler below, with numerous brown punctulations, sometimes extending over the sides of the belly, and almost blackening the upper surfaces, and in young specimens accumulated near the lateral line. There is never seen the lateral band of the atronasus, and the space between the orbit and muzzle is blackish like the top of the muzzle and front. There is a black spot on the operculum. In spring the lips and parts of cheek of the males, with the paired fins and the caudal, are of a bright crimson. The pectorals of both sexes are lanceolate, but as in the last species, the males have the rays much enlarged; these fins are absolutely longer in this sex, attaining the ventrals, while in the females they reach only two-thirds that distance. Radial formula as in the preceding species, D. I. 8, A. I. 7, P. 15. Lateral commencing at top of operculum, decurved; scales in a Delaware specimen 14—65—8, in two Susquehanna, 12—57—7-8; the latter were rather smaller.

This species is less abundant than the last, and appears to be rather local in Eastern Pennsylvania; it prefers boisterous and rocky streams, in whose rapids and ripples it may be seen in twos and threes, and will sometimes take the hook with the spring and energy of a trout. I have taken this fish several times in the tributaries of White Clay Creek, Chester County, and have it from the neighborhood of Safe Harbor, Lancaster County, on the Susquehanna. The latter specimens are almost black above and on the sides. It is not known to occur in any tributaries of the Ohio.

I have found a species of Entomostracous crustacean, an Argulus, parasitic on this species, attached within the nareal cavity, and spread round its margin externally. J.

Stauffer has also found numerous Arguli attached to the branchiæ of an Amiurus albidus, which was in an exhausted condition.

HYPSILEPIS, *Baird.*

Plargyrus, Rafinesque, Girard, Proc. A. N. S., Phil., 1856, 195.

Mouth small, terminal; pharyngeal teeth acuminate, with moderate masticatory surface, 2.4—4.2. Anal fin short; scales moderate, extensively imbricate, leaving a small surface exposed.

This genus resembles both Leuciscus and Clinostomus, partaking of features of both, besides having those peculiar. It is distributed throughout the eastern district of the United States, and extensively in the central district, that is, to the Rocky Mountains. H. plargyrus, not included in this synopsis, may yet be found in the Alleghany River.

One of our species has been referred to the genus *Cyprinella*,* Girard, but it presents all the characters of Hypsilepis. The former genus is said only to differ from the latter in the crenulation of the edges of the teeth, and this indeed is visible in many specimens of the Hypsilepis kentukiensis, but not always, and frequently on one tooth only.

Dr. Girard, however, describes his genus as being furnished with dental serrations of an acute edge, without masticatory surface, and with a dorsal fin situated posterior to the line of the ventrals. The latter holds good to such a trifling degree in the H. kentukiensis as to be of little significance, and either this species is not properly Cyprinella, or the latter genus has no existence.

Our three species may be distinguished as follows:

Head 4—4¼ times in length to origin caudal; scales 5–6, 35–40—3; teeth more or less crenate, outer row 1—1; muzzle more acuminate; black spot on dorsal fin behind. KENTUKIENSIS.

Head 4¼ times in length, muzzle more obtuse; scales 8—41—3; teeth never crenated, outer row 2—2; no black spot on dorsal fin. CORNUTUS.

Muzzle plane above, mouth descending; orbit 3.5 in head; tubercles minute; scales 9—44—3; anal $10\frac{1}{1}$; dark above, reddish below, base of dorsal black. DIPLÆMIA.

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* Proc. Acad. Nat. Sci., Phila., 1856, 196. *Moniana*, Ibidem, 199. This genus, if such it be, is chiefly diffused south and west of the Mississippi.

HYPSILEPIS KENTUKIENSIS, *Rafinesque.*

Leuciscus Kentukiensis, Kirt., Bost. Journ. Soc. Nat. Hist., 1845, 27.
Cyprinella do., Cope, Proc. Acad., Phila., 1854, 279.
Cyprinella analostana, Girard, Proc. Acad., Phila., 1859, 58; Cope, l. c.



The dorsal and ventral outlines are regularly and gently arched from the end of the muzzle and contract to a caudal peduncle of about the depth of the head at the middle of the orbit. The dorsal region is quite compressed, the ventral narrow but not carinate in front of the vent. Eye round, contained 4.5 times in length of head, and 1.5 in length of muzzle; the latter is narrow and projects slightly beyond the mouth, most so in males in breeding season. Oral margin arched, end of maxilla opposite middle of nares. The greatest depth of the body is greater than the length of the head, and enters the total (including caudal fin) four and one-fifth times. Tail short, deeply and concavely emarginate. Anal fin less developed than dorsal, its base nearly equal height of first ray, and just exceeding base of dorsal; latter a little over two-thirds greatest elevation of the same.

General color leaden silvery, darkest on the sides; the scales above and below, a dorsal band and large spot on hinder part of dorsal fin, blackish; top of head and median margin of anal fin shaded with the same. In spring and summer the inferior fins, and even the tip of the caudal, and anterior part of the dorsal, are filled with a satin-white pigment, which has a very elegant effect, and gives the fish its local name of "Silver Fin." At the same period the head and muzzle of the male are studded with small tubercles, as follows: a conic accumulation on the end of the muzzle, prolonging it; a series round the mandible, also over the orbit from an agglomeration on the preorbital bone; a double series of larger tubercles on each side the frontal region, which join between the nares and on the parietal region; scattered series on the temporal region.

Total length 3.375 inches; caudal .5; from its base to first ray of anal 1 in.; to first dorsal ray 1.44 in.; from latter to end of muzzle 1.56.

This species is abundant in the various tributaries of the Ohio; it is also common in all the waters of the Susquehanna examined (Octorara, Conestoga, Juniata, Meshopen), and in the Potomac (Girard); from the Delaware I know it from the neighborhood of Trenton (C. C. Abbott), and Philadelphia (J. Burk), and Conshohocken, on the Schuylkill. During the seventh month of the present year I watched a company of them, with a greater number of the Hybopsis procne, clearing out with pectoral fins and muzzle, a sandy basin between two roots of a stump standing in the Conestoga Creek. They were excessively active, suddenly turning from their employment and sailing off in streaming columns, when the silver-white of their fins had a pleasing and peculiar effect in the evening light. As we approached, a Tropidonotus sipedo s wam off with a luckless Hybopsis across his mouth, but soon returned to watch alternately ourselves, and the busy throng. Approaching cautiously, he struck right and left below the surface, as the minnows passed him, but often fell short, till a hungry Aromochelys odoratus, having the haste and move-

ments of a half-fed hog, came nosing his way into the midst of the unsuspecting party. They of course scattered in all directions, while he hastily explored the ground, and finding no eggs, scuttled off with the wampum snake. The latter returned, and was successfully pursuing his fishing when we left.

Dr. Girard described specimens of this species from the Potomac, as distinct from those of the Ohio, without making comparisons; I undertook to substantiate the differences, and give the following as distinctive features of the Eastern and Western fishes:

Head three and two-thirds to four times in length to base of tail. Scales $\frac{5-(6)}{2-(3)}$32—5. for the Eastern.

Head four and one-third times; muzzle more acute. Scales $\frac{6-7}{3-4}$38—40. for the Ohio type.

These represent the tendencies of the individuals of these regions correctly, but the exceptions to the rule are not rare; thus a Schuylkill specimen before me exhibits a head four and one-third times in length and has an acute muzzle, scales of lateral line 38. Seven rows of scales above the lateral lines in a Youghiogheny specimen include some abnormally intercalated, but not a true series; about half the Delaware specimens exhibit six. Four rows below the lateral line has resulted from counting an elevated abdominal series. In two Ohio specimens the anal radial formula is identical with that of the Eastern, 1.9, while in five the formula is 1.8. Thus this species exhibits an unusual range of variation.

HYPSILEPIS CORNUTUS, *Mitchell.*



Hypsilepis, Baird, Storer, Mem. Amer. Acad., v, 1855, 118. *Plargyrus cornutus*, Girard, Proc. Phila. A. N. S., 1856, 196. Fig. Storer, Trans. Amer. Acad. Arts and Sciences, 1855, t. xxi, fig. 3.

Dorsal region convex and compressed to dorsal fin, with sixteen to nineteen scales in the vertebral series; head four and one-quarter times in length to base of caudal fin, and four-fifths of greatest depth of body; vertex concave, muzzle obtuse rounded; mouth terminal, end of maxillary terminating opposite posterior nostril. From end muzzle to dorsal (first ray) seven-eighths from latter to origin of caudal. Ventrals origin exactly under first dorsal, broadly truncate, not quite attaining vent. Base of anal nearly equal its anterior ray, outline slightly concave. Base of dorsal two-thirds height anteriorly. Pectoral anterior rays shortened, medial not quite reaching the ventral. Operculum one-third higher than long. Eye, diameter one-fourth length of head, and once below its rim to upper preopercular ridge. Frontal width one-half length head above. Scales 8—41—3, about twenty-three on the dorsal line in front of dorsal fin. Radial formula D 1. 8; C. 4. 19.5. A. 1.9. V. 8; P. 1.15.

Coloration of an adult male: dorsal region as far down as the fourth row of scales dark impure blue, divided by an indistinct band of yellowish olive, one and a half scales wide, which follows the outline of the back; bordering the

dark below is a luminous line which does not attain the tail, which is very visible in the water, and from above when wet and out of water. Sides from rosy to silver-white, the scales in adults blackish at bases. Anal, ventral, and pectoral fins bright crimson in spring and summer, in males. Operculum rosy, head dark above. The males in spring have the branchiostegal membranes and the chin bright crimson.

Total average length 5 in. 7 lin.; head 1 in. 1 lin.; end muzzle to base anal 3 in.; depth at dorsal 1 in. 4 lin.; at anal 11.5 lin.

The above description is taken from an adult from the Conestoga, Lancaster County. Many Susquehanna specimens exhibit a more elongate form of head and body than specimens from the tributaries of the Delaware. They often differ from those of the Susquehanna in having a row of scales or two more below the lateral line. In Delaware specimens the head is shorter than in the latter, not more so than in the former, but the depth of the body is greater than in either, entering in length to base of tail three and one-third times; in the others four and four and one-third times. The dorsal fin is a little more anteriorly situated in the Delaware specimens, and there is a row of scales more below the lateral line than in Susquehanna specimens. With typical specimens only, these might be regarded as representing two species, and as such I have already alluded to them; but in the large number of individuals at my disposal, I find transitions in all the points. The Delaware specimens more nearly resemble the H. cornutus, figured by Dr. Storer.

This is one of the most widely distributed of our Cyprinidæ, occurring from New England through the Middle and Western States to beyond the Mississippi. In the waters of the Susquehanna and Delaware basins it is, with the Argyreus atronasus, the most abundant species. It prefers clear waters and does not haunt rapids.

The best figure of this, as well as of some of our other Cyprinidæ, is given by Dr. Storer in his excellent Monograph on the fishes of Massachusetts.

HYPSILEPIS DIPLÆMIA, *Raf.*

Leuciscus diplæmia, Raf., Ichthyologia Ohiensis, 50. Luxilus do., Kirtland, Bost. Journ., N. H., 1845, 276. Tab. Plargyrus do., Girard, Proc. Acad., Phila., 1856. Hypsilepis do., Cope, l. c., 1864.

This species has somewhat the form, as it has the coloration and minute nuptial excrescences, of the species of Clinostomus; as in them the dorsal fin commences slightly behind above the origin of the ventrals; its hinder margin is opposite the origin of the anal, to which the ventrals attain. Anal elongate, its last ray horizontal, outline behind, vertical concave. Dorsal elevated, rounded above, length of first articulated ray one-half from its base to base of caudal. Radial formula D. 1.9 P. 12. V. 8. A. 1.11. C.+18+. Dorsal outline elevated, superior line of cranium scarcely arched, head rather compressed; body rapidly narrowing to caudal peduncle at dorsal and anal fins. Caudal expanded deeply emarginate.

In the breeding season minute asperities cover the dorsal line in front of the dorsal fin, and appear on the upper and lower aspects of the head. The latter are most abundant on the preorbital region; on frontal region sparse minute. Rows on the superciliary and lower edge of suborbital regions, and two on each ramus mandibuli. Length of head four times in length to base caudal, and less than depth of body. Scales of anterior dorsal region much smaller than those of the lateral; latter with exposed surfaces very narrow, and crested with minute tubercles in the breeding season.

Color, dusky above, the sides and belly silvery, without band; below crimson in spring. A large black spot at base of dorsal fin. Length extends to four inches, according to Prof. Kirtland; of a specimen in Museum Academy, from Lansing, Michigan, 2 inches to origin caudal; 12.5 lines to origin dorsal; 6 lines to opercular margin; depth 7 lines.

I introduce this species on the authority of Prof. Kirtland, who states that it is abundant in all Western streams, and that it ascends rapids in shoals in spring, for the purpose of depositing its eggs.

CLINOSTOMUS, *Girard.*

Proc. Acad., Phila., 1856, 211.

As originally defined, the group bearing this name was not distinguishable from Squalius of Europe, with which I accordingly connected it. The elimination of some of Girard's characters leaves, however, a natural genus for which his name may be retained. It is represented in Pennsylvania by four species, one of which has not yet fallen under my observation. They are the most brilliantly-colored Cyprinidæ of this or any other country.

The characters of the genus as here understood, have been already given. It differs from Phoxinus principally in the large oblique mouth and prominent mandible, and the complete lateral line. The scales exhibit strong concentric ridges, and the lateral line is often much decurved, as in Stilbe.

The Phoxinus lævis is common in every stream in Middle Europe, much as Argyreus atronasus is here. It is ornamented with brilliant colors during spring. The present species are much less abundant, and are distinguished by the much larger size of their scales.

A nearer ally of the European fish exists in our country, however, than has been suspected, in a species of the same genus. This, our Phoxinus neogaeus, has not been detected in Pennsylvania, but was procured during the zoological survey of Michigan, on the ichthyology of which a report was published in the Proceedings of the Academy for 1864. Its slightly oblique mouth indicates affinity with Clinostomus. As these species bear considerable external resemblance to those of Chrosomus, they may be superficially compared thus:

Clinostomus margarita. Scales largest, head shortest, no dark lateral band.

*Phoxinus neogaeus.** Scales small, head short, lateral line half-way to dorsal; a dark lateral band from muzzle to caudal.

Chrosomus erythrogaster. Scales smallest, head elongate, muzzle prominent, lateral line short; two dark-colored lateral bands from orbit to caudal, separated by a silver band; unicolor.

Chrosomus eos. Scales smaller, head moderate, mouth shortest, muzzle not prominent; one dark band from orbit to caudal, without silver band on caudal peduncle; back spotted.

The species of Clinostomus known to the author are the following:

a. Eye small, one-fourth length of head.

Posterior opercular angle less than right; mandible compressed, much projecting; scales 10—62—5.

PRORIGER.

aa. Eye larger, one-third length of head.

Posterior opercular angle right or larger; mandible not compressed, scarcely prolonged; scales 9—46-50—4; muzzle acuminate, muzzle reaching line of pupil; a light and dark lateral band. FUNDULOIDES.

Posterior opercular angle right; mandible not compressed; muzzle obtuse; maxilla not reaching line of orbit; scales 11—58—8-9; no dark lateral band.

MARGARITA.

In the C. margarita and C. funduloides the edges of the pharyngeal teeth are frequently hyaline and sometimes so obtuse as to give an erroneous impression of a grinding surface.

CLINOSTOMUS PRORIGER, *Cope.*

Squalius proriger, Cope, Proc. Acad. Nat. Sci., 1864, 280.

In this Cyprinoid the prolongation of the lower jaw is very great: it presents a symphysial knob beyond and above the premaxillary border. End of the maxillary opposite the middle of the pupil. Angle of opercular outline less than 90°. Head narrowed anteriorly; eye four times in its length: latter four times in length to concavity of tail. Greatest height 5¼ times in the same. Ventrals a little in advance of dorsal: from front base of

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* Phoxinus neogaeus, *Cope.* *Chrosomus eos,* m. Proc. Acad. Nat. Sci., Phila., 1864, 281 (not 1861, 523).

Head more than one-fourth length to base of caudal. Parietal region broader, width one-third from first dorsal ray to caudal, which equals from dorsal to posterior margin of orbit. Muzzle short, mouth oblique, reaching edge of orbit. Scales above lateral line 18 rows, transverse series 77, longitudinal 30. Greatest depth of body, enters length to basis of caudal a little over four times. Eye contained three and a half times in length of head, diameter greater than length of muzzle from its anterior rim. Radial formula D. 8, C. 18, A. 8, V. 8, P. 16. Lateral line crossed twenty-four rows of scales. A blackish band along the lateral line, above this yellowish-brown, lighter next the band; back unspotted. A dark spot at base of tail; suborbital and opercular regions with a bluish reflection. Teeth 2.5—4.2.

Total length 2.75; length caudal .5; base of latter to origin first dorsal ray 1; from latter to end of muzzle 1.25. The pectoral extends about half way to ventrals; latter not to vent; dorsal and anal small.

This species differs from Ph. lævis by its scaly vertebral and ventral regions, and much shorter lateral line.

Specimens from New Hudson, Livingston County, Michigan.

latter to base of tail equal from former point to half way between end of muzzle and nares. Scales small, with especially strong concentric lines, 10—62—5. Dorsal high 1.8; caudal deeply furcate, 19; anal rather elongate, 1.8$\frac{1}{4}$. V. 8, not reaching vent; P. 14, elongate. Total length three inches, large specimens four and a half inches.

In spirits, rufus brown above half way to the lateral line; a dark shade from end of muzzle to tail, covered with silvery, the latter extending to the belly. Sides punctulate anteriorly.

In spring and summer the belly and sides to above the lateral line are of a bright crimson. Teeth in two specimens 2.5—4.1.

This species occurs in some of the tributaries of the Ohio, and has not been seen in any of the waters more eastwardly. It has apparently been formerly not distinguished properly from the C. elongatus of Dr. Kirtland, unless it be the *Leuciscus productus* of Dr. Storer. Kirtland's description applies equally well to both species, while his figure does not represent the proriger. I have seen several specimens of the C. elongatum, which exhibits a shorter head and jaw than the present fish, but have none at hand from which to draw a description. It occurs in some Western States, and probably also in Western Pennsylvania.

CLINOSTOMUS FUNDULOIDES, *Girard.*

Proc. Acad. Nat. Sciences, Phila., 1856, 212.



Orbit one-third head, which is equal greatest depth, and one-fifth length, including caudal. Mandible projecting beyond premaxillary; maxillary extending to opposite pupil. Posterior angle of operculum right. Caudal fin rather elongate; its furcation one-third its depth. Anterior dorsal rays two and one-fifth times in length from their basis to that of caudal; longest anals two and one-half the same distance. Dorsal outline arched to first dorsal ray; caudal peduncle rather narrow, its depth three and one-quarter times from median base of caudal to first anal ray. The operculum is considerably longer than high; the orbit round, as long as the muzzle in advance of it, and nearly equal the interorbital width. Dorsal and anal fins with short basis and long rays, latter nearly as long as former; basis of dorsal half its longest rays; a little more than half same in anal fin, ventrals reaching anal and pectorals ventrals. A male in breeding dress is quite rugose, like the Hypsilepis diplæmia, with tubercular points on the back and sides, and the rays of the dorsal and anal fins. The thoracic and branchiostegal regions, with the lower part of the operculum, are thickly studded, and on the top of the head they are of equal size and irregularly arranged to about six in transverse directions. The fissure of the mouth is large, the end of the maxillary opposite the anterior rim of the pupil. The lateral line is more strongly decurved in this species than the last, and rises distinctly opposite the origin of the ventrals.

Above dusky to the lateral line, with a light (? yellow or red) band from the superior opercular angle, above the lateral line to the tail. Below lateral line, chin, suborbital, and subopercular region yellowish; red in spring. Dentition 2.5—4.2.

I have several specimens of this handsome species from the Octoraro, a fine tributary of the Susquehanna, which separates Chester and Lancaster Counties. I have also seen a specimen from the White Clay Creek, in Chester County, tributary of the Delaware,

which is preserved in the museum of my friend Vincent Barnard, of Kennett Square. This is the best local collection of the vertebrata of our section with which I am acquainted. Few regions can boast of more numerous and beautiful streams than Southeastern Pennsylvania, there being no less than nine, omitting several of minor size, between the Schuylkill and Susquehanna Rivers. The wanderer on their banks traverses alternately the forests of numerous species of Quercus, Carya, and Fraxinus, with tangled underbrush of Kalmia and Smilax, the cultivated fields, and the jungles of Asclepias, Eupatorium, Cassia, and Rudbeckia, gorgeous with red and gold.

The Susquehanna tributaries yield the greater variety of species and number of individuals to the ichthyologist. In the rocky beds of the Octorara and Elk, gaudy shoals of this active species and the Hypsilepis contrast with the dusky Exoglossum and the solitary stone catfish (Noturus), which love concealment, and are only seen when disturbed, darting from stone to stone. These streams have not been so obstructed by dams as most others, where the erection of vertical breasts near their mouths has almost completely deprived them of their anadromous species of fish. The destruction of the shad fishery in the Susquehanna was a result of this shortsighted practice; as the interest was large, the legislature finally interfered, and the dam was removed, and similar obstructions in the tributaries of this river directed to be taken away. Reckless destruction of fish in the tributaries of the Alleghany has resulted in a strict enforcement of the game laws, but neither protection has yet been actively applied to the Delaware tributaries.

The building of oblique breasts to the dams would enable numerous species to pass up which are now prevented, and the harmony of nature would remain undisturbed, greater purity of the water insured, and no mean source of food preserved and developed.

CLINOSTOMUS MARGARITA, *Cope.*



The muzzle obtuse, mouth oblique, scarcely attaining the line of the anterior margin of the orbit. Head four times in body to base of caudal fin, equal the greatest depth. Eye three-fourths its diameter from end of muzzle, and equal postero-inferior margin of operculum. Scales less exposed on anterior than posterior regions, and covering the inferior regions; 11—58—8-9. The lateral line is discontinued 5-8 scales anterior to the caudal fin. Pharyngeal teeth slender 2.5—4.2. Dorsal originating behind origin of ventrals, 1.8. C. 19. A. 1.8. V. 8, extending three-fourths from their origin to the anus; P. 17, reaching two-thirds way to ventrals.

From origin caudal to that of first dorsal ray 12 l.; from latter to opposite posterior margin orbit, 9.5 l.; from same to end muzzle, 13.5 l.; base first anal ray to base of caudal, 8 l.; end muzzle to base ventrals, 12 l.; total length 2 in. 6 lin.

Coloration, above light olive, without dorsal line, but darker shade at origin dorsal fin, with a minute slaty dusting, and a few lateral speckles of the same. Sides to half way above the lateral line with opercula, plumbeous silvery; below bright crimson (in midsummer) to lower margins of pectoral and ventral fins; median line below, straw-colored. Muzzle blackish; fins unspotted.

I have only seen this fish from a tributary of the Conestoga, near Lancaster, Pennsylvania, which it inhabited with Argyreus, Semotilus, etc.

PHOTOGENIS, *Cope.*

This genus is the ally of Hybopsis, from which it differs in the sharp-edged pharyngeal teeth, which contrast with the marked masticatory dentition of the latter. The mandible is projecting and the mouth oblique, while in Hybopsis the mouth is usually horizontal or slightly inferior; in H. hæmaturus, however, it is terminal, and in H. heterodon and H. plumbeolus (*Alburnops*, m. l. c., 282) oblique, and the under jaw slightly projecting. It is therefore probable that further investigation will be necessary to establish this, as well as the allied genera, on firmer bases, though their recognition is not difficult with present material.

Scales 5—39—3; depth one-sixth length to base of caudal; equal from muzzle to preopercle; ventrals far short of anus; dorsal immaculate, a lateral satin band; lateral line little decurved. LEUCOPS.

Scales 7—35—3; depth four and three-quarters to base of caudal, equal from muzzle to front of opercle; ventrals not to anus; dorsal fin unspotted; sides and below silvery; lateral line much decurved. ARIOMMUS.*

Scales 6—38—2; depth one-fifth length to base of caudal, equal from muzzle to middle opercle; ventrals to anus; dorsal with black spot behind; no lateral satin band. SPILOPTERUS.†

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* Photogenis ariommus, Cope, sp. nov.

This species resembles at first sight the Ph. leucops, but is less Alburnus-like. On comparing with an example of the latter, .25 longer, the depth of the body is the same, and the eye strikingly larger; the depth of the head the same, and the muzzle shorter.

In this fish the opercular is deeply concave on its upper posterior margin, and the inferior is shorter than the anterior; in P. leucops the former is straight, and the inferior border equal the anterior. The dark lateral line is faint or wanting in the ariommus, and there is no black vertebral band. Placed alongside of a Hypsilepis cornutus of equal length, this fish is less deep, and has an eye of almost double the area, besides the different coloration and generic features of teeth and scales.

Eye two and three-fifths in length head; muzzle two-thirds its diameter; mouth large, mandible scarcely projecting, maxilla not attaining anterior margin of orbit. Frontal breadth three-fifths orbit. Pectoral fins reaching three-quarters distance to ventrals. Depth caudal peduncle one-third from middle origin caudal to opposite first anal ray. Basis of anal slightly elongate, four-fifths height of same, equal basis dorsal; latter equal two-thirds height of dorsal; last dorsal ray much less than half first, hence the outline of the fin is very oblique. Caudal deeply furcate, length equal that of head.

Light olivaceous sides and below silvery, becoming a band with superior dark edge on caudal peduncle. Sides of head and muzzle white. Total length 2.875 inches; base of dorsal to superior base caudal 1.06 inches; same to end muzzle 1.19.

† Photogenis spilopterus, Cope, sp. nov.

PHOTOGENIS LEUCOPS, *Cope.*

Squalius (*Clinostomus*) *photogenis*, Cope, Proc. Acad. Nat. Sci., Phila., 1864, 280.



A species resembling some Alburni in its large caducous scales and attenuated form. Eye one-third head, round. Mouth quite oblique; under jaw scarcely projecting; maxillary not reaching line of margin of orbit. Head entering four and two-thirds times into length to fork of caudal; greatest depth seven times. Back broad. Fins D. narrow 8; C. 19, A. 1—10. V. little anterior to dorsal 9. P. narrow falcate 13, extending about half way from their origin to that of the ventrals. Scales with radii stronger than concentric lines.

From base of caudal to base of first dorsal ray, equal from latter to anterior border of iris. Lateral line deflexed, rising with outline of belly at anal fin. Above pale ochre, with a median brown line, and one on each side, from opercular upper angle to tail. Sides and below bright silvery, especially brilliant on the operculum and suborbital region. Lips blackish edged. Muzzle and chin whitish. Length three inches.

In two specimens the pharyngeal teeth are arranged 1.4—4.1. This bright species occurs, so far as known, in tributaries of the Alleghany River only; those which we possess are from the Youghiogheny.

It is readily distinguished among our numerous small silvery species, resembling in a slight degree only the Alburnellus rubrifrons. This has a shorter, deeper body, longer muzzle, smaller eye, etc.

HYBOPSIS, *Agassiz.*

Amer. Journ. Sci. Arts, 1854, 358. Putnam Bullet. Mus. Comp. Zool., No. I, p. 9. *Hudsonius*, Girard, Proc. A. N. Sci., Phila., 1856, 210. *Alburnops*, Girard, l. c., 194.

Form elongate, less so than in the Ph. leucops; scales with the radii distinct 6—10, and the concentric lines very strong. Lateral line deflexed anteriorly. Orbit three and one-half times in length of head, equal length muzzle, and is three-fourths the interorbital breadth. Head five and one-third times in total length, equal length caudal fin. Muzzle straight above, mandible not projecting when closed, end of maxillary attaining line of orbit. Premaxillary margin opposite middle pupil. Pectorals two-thirds length to ventrals. Bases of anal and dorsal fins equal, equal two-thirds height of former, three-fifths height of latter. First dorsal ray a little nearer origin caudal than end muzzle. Rays, D. 1.8. A. 1.8. V. 7 and 8. P. 13.

Length 2.875 inches, depth caudal peduncle at middle .19 in. Teeth in numerous specimens 1.4—4.1.

Color olivaceous, with a plumbeous band along the posterior half the lateral line; thoracic region and lower half the sides of head silvery, remainder of head blackish. Median part of caudal fin, a spot on the upper hinder portion of the dorsal, and a narrow vertebral line, black.

Many specimens of this species are in Museum Academy, from the St. Josephs River, in Southwestern Michigan.

This species bears a superficial resemblance to the Hybopsis plumbeolus, but apart from the difference of dentition, and the spot on the dorsal fin, this species has a smaller eye, longer ventrals, etc.

Mouth (typically) very small inferior, without barbels; pharyngeal teeth always hooked, and furnished with masticatory surface, latter sometimes on two teeth only, 0.4—4.0, 1.4—4.0, or 1.4—4.1, 2.4—4.1, and 2.4—4.2. Scales large or moderate, a large surface exposed; anal fin short. Length of alimentary canal a little less than length of head and body.

As deviating from the ordinary form, H. hæmaturus has the mouth terminal, and H. heterodon the mandible longer, and mouth slightly oblique backwards; it is indeed questionable on this account whether the latter belongs to the genus. The dentition, so far as known, is as follows: Teeth 4—4, H. hæmaturus, stramineus, dorsalis, regius, procne, volucellus; sometimes with one inner on one side, heterodon; 1.4—4.0 storerianus; 2.4—4.1 hudsonius, 2.4—4.2 H. chalybaeus, plumbeolus; of the above the masticatory surface is most extensive, and the hook shortest in H. hæmaturus and H. tuditanus, which thus approximate Hybognathus. In the species of that group the head is more massive; in the procne type the head is narrower, and the body more compressed, while in sects. A, B, and C in part, the orbit is longitudinally oval.

The genus, indeed, bears much resemblance to Hybognathus, and several of its species have been described under the latter head by Girard and myself. Most of them are of small size, and all of weak organization. They are ornamented rather with lustre, than hue, for I am not acquainted with any which display the bright colors of the Clinostomi and Argyrei. They occur throughout those regions of the United States east of the Rocky Mountains which have been as yet examined.

The natatory bladder occupies the whole length of the abdominal cavity in the species examined. Food, insects and crustaceans.

Allied to this genus by the structure of its dorsal fin, alimentary canal, and teeth, is Cochlognathus, Baird and Girard. It differs in the peculiar character pointed out by Girard, the entire cutting edges of the jaws. The appearance of the known species is much that of Hyborhynchus.

I. Head 5.5 to 6 times in length (including caudal fin).

Pectoral fins not reaching ventrals.

A. Teeth +4—4+; mouth small inferior; lateral line complete; a broad lateral silver band.

Scales 6—38—3-4; teeth 2.4—4.1; eye three times in head; head five and two-thirds in total; muzzle descending in profile, sometimes very obtusely. A. 8: squamosal region prominent. HUDSONIUS.

Teeth 1.4—4.1; head one-sixth the length; eye one-fifth head; A. 9. STORERIANUS.

II. Head 4.5 to 5 times in total length.

B. Teeth 4—4; mouth inferior or horizontal, small; lateral line complete.

a. Pectoral fins not reaching ventrals.

Scales 7—43-4—4, not dark edged, 27 in front of dorsal, which is markedly nearer caudal than end of muzzle; muzzle very obtuse, mouth very small inferior; sides silvery, often with a dark band; no dorsal band, a dark

spot on middle of front dorsal rays, and faint one at base of caudal; parietal region broad, flat, temporal angled; eye 3.5 in length head, which enters 4.5 times to base caudal. TUDITANUS.*

Scales 5—36—4, 15 rows anterior to dorsal fin, which is equidistant between base of caudal and end of muzzle; muzzle very obtuse, mouth moderate; sides silvery; often a median dorsal band, no spot on dorsal fin; parietal and temporal region rounded; eye larger, three times in head, which is four times to base caudal. STRAMINEUS.

"Mouth protractile downward; snout pointed; a deep black band from nape to base of dorsal, round both sides of it to median line again; olive, sides silvery, a deep rose-colored spot at base of dorsal fin." (Agassiz.) DORSALIS.

Scales 5—31-3—3, 13 rows in front of dorsal, a dorsal line and burnished plumbeous lateral band, with blackish pigment below; teeth 4—4; eye one-third longer than deep; head one-fifth total, front decurved, obtuse, mouth horizontal, mandible shorter; caudal peduncle slender, its median depth one-fourth length from first anal ray, A. 7. PROCNE.

aa. Pectoral fins attaining ventrals.

Head flattened, elongate; eye contained three and one-third times; head to base caudal three and three-fourths; scales 4—34—3; dorsal length half from its first ray to base caudal; caudal peduncle slender; no dorsal band; a darkish lateral. VOLUCELLUS.

"Head broad, nearly one-fourth length; snout short, broad; eye one-third head, line of margin reached by maxillaries; caudal peduncle slender." (Agassiz.) GRACILIS.

C. Teeth 4—4; mouth obliquely descending; lateral line complete.

Scales 7—44—4, blackish-edged above lateral line, 21 rows in front of dorsal, which is nearer caudal than end

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* Hybopsis tuditanus, m. sp. nov.

This is an abundant species, and has so much the aspect of Hyborhynchus notatus, as to be readily mistaken for it; its resemblance consists in the broad flat head, and angulated temporal region, size of scales, rounded muzzle, and even in dentition, but the latter differs *toto cœlo* in the structure of the alimentary canal and dorsal fin, form of the scales and the tubercles, and great thickening and obtuseness of the muzzle.



Cranium flat above, temporal width 1.5 in length above, and equal length from end muzzle to posterior margin of orbits. Dorsal fin lower than usual, height anteriorly equal its basis, six-sevenths of to equal height of anal, and three-fourths length of caudal; basis of anal three-fifths basis dorsal. Greatest depth 5.33 times to origin of caudal. Muzzle rounded, very obtuse in profile, broad as two-thirds parietal width. Mandible short, outline slightly angulated in front.

Total length 3.1 in.; from end muzzle to first dorsal ray 1.375.

Olivaceous above, dorsal scales narrowly black-edged; no vertebral band; sides and below silvery. The types of this species were procured in the Detroit River; these with numerous others, from the St. Josephs, exhibit a dark lateral band extending from the end of the muzzle to the base of the caudal fin, especially dark on the operculum. Specimens from the Wabash at Lafayette, Indiana, where I have taken it in large numbers with the Hybognathus nuchalis, Agassiz, do not exhibit this lateral line. In all is a basal caudal spot, and dark spot at middle of anterior dorsal rays, the latter very indistinct in young specimens.

of muzzle; muzzle little obtuse, mouth moderate, terminal, maxilla to orbit; no lateral silver band or dorsal spot; a caudal basal spot; tail red; temporal region rounded. A. 1.7. HÆMATURUS.*

"Scales 6—38—4; head one-sixth total length; teeth 4—4;" mouth oblique, large; A. 11.9. REGIUS.

Form compressed; vertex convex; scales 6—35—3; eye 3.5 in length head, which enters four times to origin of caudal; ventral fins to vent; a lead-colored lateral and dorsal band. A. 1.8. FRETENSIS.†

D. Teeth +4—4+; mouth obliquely descending; lateral line complete.

Form compressed; vertex convex; scales 6—39—3; eye 2.75 in length of head, which is over four times in length to base of caudal; depth 4.66 in same; ventral fins not reaching vent; no lateral or dorsal bands. A. 1.9. Teeth 2.4—4.2. PLUMBEOLUS.

Scales 6—35-6—3, 17–19 rows in front of dorsal; muzzle nearly flat, mouth oblique, to opposite orbit; eye one-third head; lateral line decurved complete, caudal peduncle slender; teeth 2.4—4.2; A. 1.8. Brown, a burnished broad black band from tail to muzzle, light-bordered above on the latter. CHALYBAEUS.

E. Teeth 4—4; mouth obliquely descending; lateral line imperfect.

Scales 5—36—3, 13–14 vertebral in front of dorsal; a blackish rostral and lateral band; eye three times in head; head about equal depth, four and three-fifths in total length; maxilla to opposite orbit; muzzle acuminate, flat, mouth oblique, lip opposite upper rim of pupil; mandible a little longer; back compressed elevated; caudal peduncle stout; lateral line posteriorly imperfect; anal 8. HETERODON.

Scales 5—36—3, 12–13 rows crossing anterior to dorsal fin; muzzle very obtuse, shorter than orbit; mouth oblique, top of arch opposite lower rim of pupil; eye one-third head which is equal depth and four and one-fifth times to base of caudal; teeth 4—4. A. 7. Anterior fifth of lateral line existing; straw-colored, with a black band on sides and round muzzle, orange-bordered above on latter region. BIFRENATUS.

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* Hybopsis hæmaturus, m. sp. nov.

Eye three and one-half times in head, which measures four times to origin of caudal. Temporal width one and three-quarter times from nape to end muzzle. Greatest depth four and four-fifths in length to base caudal. Lateral line very slightly deflexed, rising opposite hinder rays of dorsal. Basis of dorsal three-fifths height anteriorly, near four-fifths front of anal. Anal basis short, rays 1.7.

Above blackish lead-color; head above, and behind, and before orbit, blackish; a faint blackish band on middle of sides from last dorsal rays to caudal, a basal dorsal spot, continued as a line on the fin; head below and median line of body whitish. Total length 2.75 in.

This plain species is abundant in the St. Josephs River, Michigan, and at Michigan City, Indiana. Its dull red tail is a noticeable feature of coloration.

† Hybopsis fretensis, Cope, sp. nov.

General appearance, that of Alburnellus. Lateral line decurved, its course on the caudal peduncle below the middle line. Seventeen rows of scales in front of the dorsal fin; scales of body with concentric stronger than radiating lines. Mouth quite oblique, middle premaxillary line opposite middle of pupil; maxillary not attaining line of orbit. Length muzzle equal diameter orbit. Pharyngeal teeth more or less crenate; external angle of the pharyngeal bone scarcely projecting.

Total length 2 in. 4.5 lines; end of muzzle to basis ventrals 10.85 lines; to basis anal 1 in. 4.5 lines.

Reddish-olive above, with a dark median dorsal band; lateral leaden silvery band, not distinctly defined; opercular apparatus and pre- and sub-orbital regions brilliant silver; below less brilliant; a dark spot at base of caudal.

A single specimen of this species is in the Museum Academy, from near Detroit, Michigan.

Of the above species which do not enter our limits:

Hybopsis stramineus is *Hybognathus stramineus* in Proc. Acad. Nat. Sci., Phila., 1864, 283. In the description of this species, l. c., the position of the dorsal fin is erroneously described, and is as now corrected. A number of specimens also from Detroit River, exhibit a vertebral band from nape to caudal fin.

H. heterodon, *Alburnops heterodon*, Cope, l. c., 281. The variation in the structure of the teeth which I have mentioned under the original description, may be thus accounted for: the crenate teeth are immature, as occurs in other genera; those without masticatory surface are rare, perhaps also immature.

H. regius, *Hybognathus regius*, Girard. This species has strongly-hooked teeth, as exhibited in preparation in Museum Surgeon-General, Washington, D. C., and the mouth is scarcely inferior, hence neither a Hybognathus nor typical Hybopsis.

H. volucellus, *Hybognathus volucellus*, Cope, l. c.

Alburnus nitidus, Kirtland, Cleveland Annals Science, probably belongs also to Hybopsis.

HYBOPSIS CHALYBAEUS, *Cope.*

Head 3.8 (sometimes 4) times in length to base of caudal; length of latter equal from opercular margin to nares. Muzzle shorter than diameter of orbit, slightly acuminate, and exceeded by the tip of the mandible when viewed from above; head flat above, less angulate on the temporal region than many species, the superior plane narrower there than between the orbits; supraopercular region oblique. Teeth slightly hooked, masticatory surface well marked, upper tooth nearly opposite angle of the ala. Dorsal fin elevated, with eight rays a very little behind above ventrals; latter pointed, reaching anal. Anal slightly elongate, exceptionally with nine rays; pectorals pointed, not reaching ventrals. Superior outline rising to dorsal fin, then immediately descending, forming with the nearly parallel ventral line, the elongate caudal peduncle. Caudal fin deeply forked.

The broad burnished black lateral band does not descend below the lateral line on the middle of the body; it occupies one and two half rows of scales. Above it on head and body the color is fulvous brown, excepting a straw-colored crescent from orbit to orbit round the nose; terminal half of mandible black; sides of head below, silvery, of body straw-colored; no distinct vertebral stripe, or spots on the fins.

This is a very small species, nearly the smallest of the Cyprinidæ; a specimen before me, apparently fully grown, measures only 1 inch 8.5 lines in total.

Several specimens of this species were taken in a tributary of the Schuylkill River, near Conshohocken, by Charles H. Darlington, and the museum of the Academy possesses numerous others.

This species is most allied to the H. heterodon, and in less degree to the H. procne; very careful examinations of large numbers of specimens of the three convince me of the value of the characters adduced.

I have satisfied myself that the H. chalybaeus cannot be the fry of any species known

to me. The scale formula and form of head in the H. hudsonius are quite different; the appearance as well as details of the living fry of Hypsilepis cornutus and kentukiensis from the same waters, is entirely distinct. In general the characters are most like those of the last named; leaving out of view the generic difference in the form of the scales, specimens of nearly the same size may be distinguished as follows:

H. kentukiensis.	*H. chalybaeus.*
Dorsal outline continuous beyond dorsal fin; caudal peduncle deep.	Dorsal outline depressed beyond dorsal fin, forming slender caudal peduncle.
Eye three and two-thirds times in head.	Eye three times in head.

The coloration of the young kentukiensis is identical with that of the adult, and entirely different from that of the present species.

The Hybopsis chalybaeus is much less abundant than the H. procne; I have not yet seen it sold for aquaria, in which it would, however, be a greater ornament. The stomach of a specimen opened, contained minute insect larvæ.

HYBOPSIS BIFRENATUS, *Cope.*

This small species agrees in dentition, squamation, and radial formulæ with the H. procne, but differs in the deeper body, more oblique mouth, the almost absence of the lateral line, and in coloration. Its affinities are really nearer the H. heterodon, from which the points of the table will distinguish it; while its general appearance is surprisingly like the H. chalybaeus.

Color above straw, the scales delicately brown-edged; below impure white, with a narrow black line along base of anal fin to caudal. Along each side from the caudal fin round the end of the muzzle, including the end of the mandible, a shining black band, one and one-half scales in width. This is bordered above on the muzzle, forming an arc from orbit to orbit by an orange band, which is strongly margined above by the brown of the top of the front. Opercular and suborbital regions below the black band, pure silvery.

Front convex between the orbits; length of muzzle equal diameter of iris band and pupil, sometimes nearly equal orbit. Iris colored in continuation of the lateral band. The lateral line rarely extends half way to the dorsal fin, while the pores of the same may be observed at the bases of the scales for half the remaining length of the animal. Length of the largest specimen, nineteen lines; breadth of muzzle at nares 1.5 lines. Radii of the scales strong.

I have examined carefully at least one hundred individuals of this species which I took near the mouth of a stream which flows into the Schuylkill at Conshohocken, in company with Hybopsis procne and Hypsilepis kentukiensis. Large numbers of the three were taken, from young of six lines in length to nearly adult age of the last mentioned. The

young of the H. bifrenatus and H. procne are readily separated, since the latter species exhibits its form and its lateral line in specimens of seventeen lines long and upwards, as well as its color. The H. procne is more silvery, and exhibits from the smallest size upwards a silver lateral band with black specks at the bases of the scales.

The dentition of these species, like that of the Hypsilepis kentukiensis, does not vary from the formula at any age. The lateral line is, however, wanting in both Hypsilepes, smaller than nine lines, and H. procne below seventeen lines. I am inclined to anticipate that the H. bifrenatus will be found to attain a rather larger size, though most likely one of the smaller Cyprinidæ. My specimens were taken in the beginning of winter.

HYBOPSIS PROCNE, *Cope.*

Hybognathus procne, Cope, Proc. A. N. S., Phila., 1864, 279.

This small species may be readily distinguished among others common in our streams by its long caudal peduncle and tail, its large brown-edged dorsal scales, and plumbeous lateral band.

The dorsal region is compressed and slightly elevated at the dorsal fin, and the muzzle strongly obtuse; the eye is large and longitudinally oval. Below white tinged with yellow. The bases of the dorsal and anal are five-eighths to one-half the length of the first rays of those fins, and the bony ray of the former is two-thirds the same height. Caudal deeply furcate, and with acute lobes. Rays D. 1, 8 A. 1, 7, constantly one less than in H. chalybaeus and hudsonius, the last being deeply fissured in the three; V. 1, 8, reaching vent; P. 12–13. Fins unspotted; a blackish line along origin of anal, and continuation of lateral band on base of caudal.

This species rarely attains 2.5 inches; a common length is 2.187, of which caudal fin is .437; from middle origin latter to first anal ray .562; end muzzle to origin dorsal .875; this distance is sometimes less than, sometimes equal to, from latter point to origin caudal.

This fish prefers comparatively sluggish waters, and abounds in the streams of the low lands which empty into the ocean and its estuaries. In our hill country it occurs in mill-dams and coves of the larger streams, in fact, in situations not chosen by Argyreus atronasus. I have seen it from the Delaware, Schuylkill, White Clay Creek, of the Delaware basin, and Conestoga of the Susquehanna, where Jacob Stauffer originally observed it, but not farther westward.

I had thought this fish the fry of some larger species, but am now convinced of its small adult age, as being one of the smallest known Cyprinidæ. Besides having seen a great number of specimens, I have found females much distended with eggs, an observation also made by my friend, Jesse Burk. I have watched them also going through the movements of preparing a place of deposit for eggs.

Hybopsis procne is very commonly sold for aquaria in Philadelphia. I have seen it captured as food by the wampum snake (Tropidonotus sipedon).

HYBOPSIS HUDSONIUS, *Clinton.*

Amer. Lyc. M. H., New York, 1824, 49, Pl. II, f. 2, Agassiz, Putnam Bulletin, Mus., Comp. Zool., Cambridge. *Hudsonius fluviatilis*, Girard, Proc. A. N. S., Phila., 1856, 210. *Hybopsis phaënna*, Cope, l. c., 1864, 279.



I have this species from the Delaware near Trenton. It no doubt inhabits the Susquehanna, as I have procured it from the Potomac near Washington. It is in general northern in its distribution, occurring commonly in the waters of the great Lakes. Specimens from our regions have a less obtuse and rounded muzzle than some from Lake Huron and than Clinton's figure, but I incline to ascribe the more conic form to maturer age, as it accompanies increased size. There are also slight variations in the form of the operculum, some having an individual feature in the greater prolongation of its anterior inferior angle. A specimen from the Potomac exhibits the anomaly of the successional outer (or long) series of teeth having taken its place in advance of the shedding of the previous set, hence they are 2. 4. 4—4. 4. 1. Those of the outer row are without masticatory surface, those of the median as in the other species of the genus, the conic ones much truncated. Occasionally the grinding surface is found but slightly developed.

In this species the upper surface of the cranium is broad; the temporal region rounded; distance between nares about equal from anterior margin of same to end of muzzle. Eye a little less than one-third length of head; latter five and one-third times to concavity of tail, and more than equal greatest depth of body; in storerianus the head does not equal the depth, and the back is more compressed. Angle of mouth not posterior to anterior nostril. Scales 5—38—4. Lateral line very slightly deflected opposite dorsal fin. Base of caudal to posterior edge of dorsal equal from latter to beginning of skin of head. Rays D. 1.8; C. 19; A. 1.8, its outer border concave like that of dorsal; V. 19; P. 15. Lateral band and below silvery, a dark shade passing through former; no spot at base of tail. Above pale ochre, with a faint median line. Total length 4.75 inches; caudal fin one inch, its peduncle to base of anal 1.125 inches, depth half way between anal and caudal .344. End muzzle to base dorsal 1.875; same to base ventral; length pectoral .72, of dorsal .875.

A specimen from the Conestoga, half grown, exhibits some peculiarities, as a less obtuse muzzle than larger specimens from Michigan, and a lateral lead-colored band two and a half scales in width anteriorly.

Yellow olive above with dorsal line and brown-edged scales, below yellowish-white. No distinct spot at base of dorsal. Cranium and back broad.

Height of dorsal one and one-half its base, first ray (osseous) half the height, nearer end muzzle than origin caudal; base of anal more than two-thirds height of first rays.

Total length 2.875; caudal fin .5; middle origin caudal to first anal ray .78; end muzzle to origin dorsal fin 1.187.

In this specimen the differences between H. hudsonius and the H. procne, which I had once suspected to be the young, are marked. First, the invariably greater number of scales above and below the lateral line; second, the constantly normal number of anal rays; the deeper caudal peduncle, which is one-third its length from first anal ray; the broader lateral band, which is in the procne but 1.5 rows scales in width. Pharyngeal teeth I could only find 1.4—4.0. There may still be some question as to the pertinence of this specimen to H. hudsonius.

ALBURNELLUS, *Girard.*

Proceedings Acad. Nat. Sci. Phila., 1856, 193.

This genus represents and nearly resembles the Alburnus of the Old World; whether the latter genus occurs on the North American Continent or not is as yet unknown.

The dentition is represented by the formula 2.4—4.2; the teeth are without masticatory surface proper, except perhaps in A. rubrifrons. There is a narrow, scarcely worn plane in both A. jaculus and A. arge, on one or two of the teeth.

In the three species here compared the extremity of the maxillary bone reaches the vertical line of anterior margin of the orbit, and the distance from the base of first dorsal ray to caudal equals from former to posterior margin or middle of orbit.

Diameter of eye less than to muzzle, four times in length of head; head five times in total. Scales 6—39—3. A dark vertebral line, a dark lateral band, sides and belly silver. RUBRIFRONS.

Diameter of orbit less than to muzzle, 3.5 to 3.7 in length of head; latter five times in total, four and one-fourth to base of caudal. Scales 6—39—2, lateral line most decurved. No dorsal or lateral band, sides and belly silvery. JACULUS.*

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* Alburnellus jaculus, m.

A very elongate, light olivaceous species, which occurs in shoals in the clear water of the St. Josephs River, and its tributary the Dawagiac. These streams debouch into the head of Lake Michigan from the east.

Muzzle from orbit longer than diameter of latter; end of maxillare opposite anterior margin orbit, mandible acuminate without symphyseal knob. Frontal breadth two-thirds temporal, equal orbit's diameter. Greatest depth seven and a half times in length (including caudal), equal from end muzzle to preopercular border. First dorsal ray equidistant between origin of caudal and posterior rim or middle of orbit, as far behind opposite ventrals as the posterior ray is in advance of anals. Base of dorsal equal two-thirds its height; base of anal equal

Diameter of orbit greater than length of muzzle, three times in length of head; head five and one-half times in total four and one-half to base tail. Scales 5—39—3. A dark vertebral line, and defined lateral silver band.

ARGE.*

Other species described as inhabiting the United States, are;

A. rubellus, Agass., Lake Superior; A. lineolatus, Ag., Osage River; A. zonatus, Ag., Putnam's Bulletin Mus., Comp. Zool., I, 9, Osage River; A. formosus, Putnam, l. c., Mobile; A. dilectus and umbratilis, Girard, Pr. A. N. S. Phila. 1856, 193, Arkansas R.; A. amabilis, Girard, R. Leon, Texas; A. megalops, Girard, San Felipe, Texas; A. socius, Girard, Live Oak Cr., Texas. The only species known to occur in Pennsylvania is

ALBURNELLUS RUBRIFRONS, *Cope.*

Proc. Acad. Nat. Sci., Phila., 1865, 85.



The head is elongate conic and compressed, the outline of the vertex and front nearly plane, scarcely descending at the end of the muzzle; length one-fifth the total (thus differing from dilectus, Gir., one-sixth). Operculum a little higher than long. Mouth elongate, very oblique, end of maxillary opposite anterior margin of orbit; border of premaxillary above opposite middle of pupil (differing in this from rubellus, Ag.). Orbit nearer end of muzzle than to opercular border, its diameter not reaching former, and contained four times in length of head. Shape regularly fusiform, greatest depth five and one-half times in length including caudal.

Scales 6—39 + 2—3 fewer than in umbratilis, more than in oligaspis, and much as in amabilis, megalops, and socius. These species are not so elongate, have differently proportioned heads and different coloration. The lateral line has a long slight deflection as far as the dorsal fin. The pectorals do not reach the ventrals, which

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three-fourths longest dorsal and anal rays. Pectorals extend three-fifths way to ventrals, the latter do not reach vent. Depth caudal peduncle one-third from middle base of caudal fin to opposite last anal ray. Rays D. 1. 8. A. I. 10 or 11. V. 8, P. 13.

Upper surfaces half way to lateral line olivaceous, the scales darker bordered; from this point below, leaden silvery; top of head, muzzle, caudal, dorsal, and pectoral fins dusky.

Length 2.75 inches.

Habitat. Southwestern Michigan; numerous specimens Museum Academy.

* Alburnellus arge, m. sp. nov.

Also an elongate species, less than the preceding, with deeper head and larger eye.

Muzzle from orbit less than diameter of latter; end of os maxillare opposite anterior rim of same; mandible acuminate, not projecting when closed, no symphyseal knob. Frontal breadth two-thirds temporal, and three-fourths orbit. Greatest depth a little over seven times in total length equal from end muzzle to preopercular border. Proportions and formula of fins as in the last. Lateral line straight. A silver band along anteriorly above the latter, dark-edged above and below. Muzzle and lips blackish.

Length 2.75 inches.

Habitat. Either the Detroit River or the St. Josephs, the locality confused. Numerous specimens.

originate anterior to the dorsal, and do not extend to the anal. Base of anal more elongate than in rubellus, equal depth of body at its fourth ray. D. I. 8. C.+19+. A. 2, 10. V. 8, P. 11, the four upper rays enlarged in the spring, as in Argyreus, etc. Scales of upper surfaces covered with minute rugosities during the same season. From origin of caudal to that of dorsal equal from latter to posterior border or middle of orbit. Length 2 in. 6 lin.

Above yellowish-olive, the scales with punctulate margins; a median dorsal line. A dark lateral band has a distinct outline on the third row of scales above the lateral line, but vanishes in punctulations below; it is broader and more distinct on the caudal peduncle. From its superior border a silver reflection extends over the white abdomen. Sides of head silvery; chin, muzzle, lips, front, and vertex light vermilion during the breeding season. The bases of the fins, except the caudal, are similarly colored at this season. The pharyngeal teeth are but little hooked; in three specimens, 2.4—4.1, and in two, 2.4—4.2.

As may be supposed, this is an elegant little creature. It is found in considerable abundance in the Kiskiminitas River, and no doubt in other tributaries of the Alleghany, though I have only seen it from the former stream. Of its habits nothing is known.

STILBE, *Dekay.*

Nat. Hist. New York, 1842, Gill, Canadian Naturalist, 1865. *Plargyrus*, Rafinesque. Ichthyologia Ohiensis, Putnam Bulletin Mus. Comp. Zoology, No. I. *Luxilus*, Raf., Girard, Proc. A. N. S. Phila., 1856.

This form is readily distinguished externally by the elevation and compression of the body and length of anal fin; the head is small, and the mouth oblique and superior or terminal. The ventral fins originate further in advance of the line of the dorsal than usual; the isthmus is moderate.

STILBE AMERICANA, *Linnæus.*

Cyprinus americanus, Syst. Nat., 1766. *Cyprinus chrysoleucus*, Mitchell, 1815. *Abramis versicolor*, Dekay. *Leucosomus americanus*, Girard,* 1853.

Scales rather large, (9—)11—46—4, radii 4–6, much stronger than the numerous, close concentric lines. Lateral line much decurved, not occupying even the middle of the caudal peduncle. Head slightly concave between the orbits, contained five and one-fifth times in length to end tail, occipital region very convex above preoperculum. Eye round, three and two-thirds in length of head, once in muzzle; end of os maxillare in line with nares. Preorbital bone a trapezium higher than long. From origin of dorsal to median base of caudal equal from former to opposite posterior margin of orbit; its base one and



* Putnam Bulletin Mus. Comp. Zool., l. c., includes *Leuciscus boscii* as synonymous with the present species, but erroneously, as it is probably a Lavinia. Vid. Pr. A. N. Sci. Phila., 1864, 283.

three-fourths height of first ray, and two-thirds base of anal, its superior outline straight; first (soft) anal ray just equal base of anal; exterior outline of latter concave. Pectorals extend two-thirds the distance to ventrals, and latter to vent. Rays D. 1. 7$\frac{1}{1}$, A. 2, 14. V. 9, P. 16. Twenty rows of scales between isthmus and ventral fins.

The upper surface of the head in back are in this species usually blackish, and the rest of the body with greenish, brassy, or golden lustre, the latter always on specimens from sluggish and muddy streams.

This Stilbe rarely exceeds seven inches in length. In a specimen five and five-sixteenths inches long, the caudal fin measures one inch, caudal peduncle to last anal ray .75; depth at latter point nine-sixteenths; depth at first dorsal ray one and three-eighths; at middle of pectoral 1.25; at occiput .875; length base of anal thirteen-sixteenths inch.

This species is called minnow or shiner, and inhabits all the waters of our State. In our rapid rivulets it is rarely seen of large size, and chiefly seeks the "cut offs" and ditches which produce Anacharis and Nuphar (Splatterdocks). It is properly a fish of the dams and ditches, and the sluggish streams near the coast, where it is extremely abundant. In the ditches near Philadelphia a mischievous mode of taking it, practised by boys, is to feed them with dough mixed with ground Cocculus Indicus.

It is abundant throughout New England and the West, and has been brought from Lake Whittlesey, Minnesota, by Dr. J. H. Slack, of this city. I have not been able to distinguish a S. compressa among our numerous specimens from Indiana, Michigan, etc.

CHROSOMUS, *Rafinesque.*

Ichthyologia Ohiensis, 47, Agassiz, l. c., 225.

Pharyngeal teeth with extensive masticatory surface, 4–5 or 5–5, no outer row; scales very small, largely exposed, lateral line very short or none. Basis of anal fin short, dorsal above the space between ventrals and anal. Mouth small terminal; isthmus narrow.

Prof. Agassiz, who characterized this genus first, affirms the teeth of the C. erythrogaster to be arranged 5–5; in nine specimens, however, I find but two with this arrangement, and seven 4–5; the number is 5–5 in the C. eos. In his paper on fishes from the Tennessee River, Prof. A. identifies a species with the former, which he says has continuous lateral line; this is perhaps a species of another genus.

Two species only are known, and both occur in Pennsylvania.

Mouth reaching opposite orbit; teeth 4—5.

Scales longitudinal rows 34—5; two dark bands separate on caudal peduncle; back unicolor; usually a lateral line. ERYTHROGASTER.

Mouth not reaching line of orbit; teeth 5—5.

Scales longitudinal rows 23; dark lines united on caudal peduncle; back spotted; no lateral line. EOS.

CHROSOMUS ERYTHROGASTER, *Raf.*

L. c., Agassiz, l. c., Cope, Proc. A. N. S. Phila., 1864, 281.



Outline from muzzle to dorsal fin gently arched and compressed, then rather suddenly descending to the elongate caudal peduncle; ventral outline nearly straight. Head slightly elongate, contained in length to base of caudal four and one-fifth times; operculum longer than high, rounded right-angled posteriorly; muzzle not quite equal an eye's diameter; latter 3.25 to .50 in length of head.

Scales small 34—5 to 80—85, concentric lines strongest, their edges on the belly so thin as to transmit the form of the base of the scale below, giving the appearance of a reversed imbrication. Lateral line extending on about 32 scales. Base of dorsal fin two-thirds its height; latter two and two-thirds times in length from first ray to base caudal; base of anal slightly longer than that of dorsal, equal depth of caudal peduncle at middle. Rays D. 1. 8, C. 19, A. 1. 9–8. P. 13, the rays on ♂ thickened, form rounded, not attaining ventrals; latter just reaching vent.

Total length 2.375 in.; end muzzle to first dorsal ray 1.06 in.; latter to origin caudal .975 in.; greatest depth at ventrals .445 in.

Above bright chestnut with a blackish vertebral line, margined below by a blackish band from the superior opercular angle straight to the upper side of the caudal peduncle; a broader black band from end of muzzle to middle caudal peduncle, decurved on side, and separated by a broad silver band from the superior; below this silvery. Both the belly and the band are in spring and summer brilliant crimson.

Specimens of this species from Illinois exhibit a more obtuse, rounded muzzle; one from the White River, Indiana, exhibits a straight muzzle, while several from Macomb County, Michigan, from waters flowing into Lake St. Clair, have a shorter muzzle, not at all decurved. The latter have also not a trace of lateral line, which is present in all the rest.

In Pennsylvania this species occurs in the Mahoning and other tributaries of the Alleghany. It is not exceeded by any of the family in brilliancy of color or gracefulness of form, and is often seen in aquaria.

CHROSOMUS EOS, *Cope.*

Proc. Acad. Nat. Sci. Phila., 1861, 523.

Another small and pretty species, representing the last in the water basin of the Susquehanna. The number of teeth 5–5, is unusual among our species.

Mouth small, not extending so far as opposite nares, chin slightly projecting; eye a little over three times in length of head, one-fifth less than interorbital width. Temporal width equal from occiput to opposite anterior margin pupil. Greatest depth five and one-third times from end muzzle to origin of caudal fin, head four times

in same. Inferior border operculum straight, one-fourth longer than posterior. Longitudinal rows of scales 23, transverse 75—8, concentric ridges stronger. Fins all quite short, rays D. 1. 8. C. 18. A. 1. 8, V. 8, P. 16. Dorsal outline nearly straight, front very gradually descending.

Specimens taken in the beginning of autumn were yellowish silvery below, as far as a dark band in the usual position of the lateral line; the latter commences at end of muzzle, and is much decurved on thoracic region. A narrower dark line on the upper lateral region confluent with the lower on caudal peduncle. Above lower band brownish interline with small brown spots.

Total length 2.312 in.; end muzzle to origin dorsal one in.; latter to origin caudal .81.

I have seen four specimens of this species from the Meshopen Creek, Susquehanna County, Pa., a tributary of the River Susquehanna.

HYBORHYNCHUS, *Agassiz.*

Am. Journ. Sci. Arts, 1855, 222.

The separation of the first bony dorsal ray is the most prominent feature in this genus, as I have pointed out, Proc. Acad., 1864, 283. The pharyngeal teeth are arranged 4—4, and often a little hooked; they much resemble those of some species of Hybopsis. The parietal region is flat, and the temporal abruptly angulated, as mentioned by Agassiz, but this occurs in almost as great a degree in some Hybopses. The genus most nearly allied is Pimephales; it agrees with it in the development of the frontal tubercles of the male taking place across the muzzle only, and in the increased length of the alimentary canal. In H. notatus the intestine presents five flexures; in P. promelas there are seven, and the length is two and two-thirds that of the head and body.

The figures given by Girard of the species he has described under this genus, do not present the peculiarity of the dorsal fin, and are either erroneous or the species do not belong to the genus.

HYBORHYNCHUS NOTATUS, *Rafinesque.*

Agassiz, l. c. *Minnilus notatus.* Raf., Ichth. Ohiensis, 47.

In Pennsylvania this species occurs only, so far as my observations have extended, in tributaries of the Ohio. I have seen it from Michigan, while Prof. Agassiz records a range of nearly all the tributaries of the Mississippi and Lakes, with Lake Champlain, and the Mohawk.

Pharyngeal teeth slightly hooked. Frontal region flat, its breadth more than half length of top of head; outline of the latter broadly truncate. Profile truncate. Eye contained four times in length of head, once between its anterior border and the end of the muzzle, a little more than half frontal width. Length of head entering four and one-half times in length to base of caudal fin, and equal greatest depth of body.

Scales 6—44-5—4, exposed portions higher than long. Dorsal fin longer than high, highest anteriorly, superior outline straight, 1. 8; caudal not deeply forked, 19; anal free border longer than anterior, 1. 7; ventrals not reaching vent, 1—8. Total length three inches. Length from base of caudal to anterior base of dorsal greater than from latter point to end of muzzle.

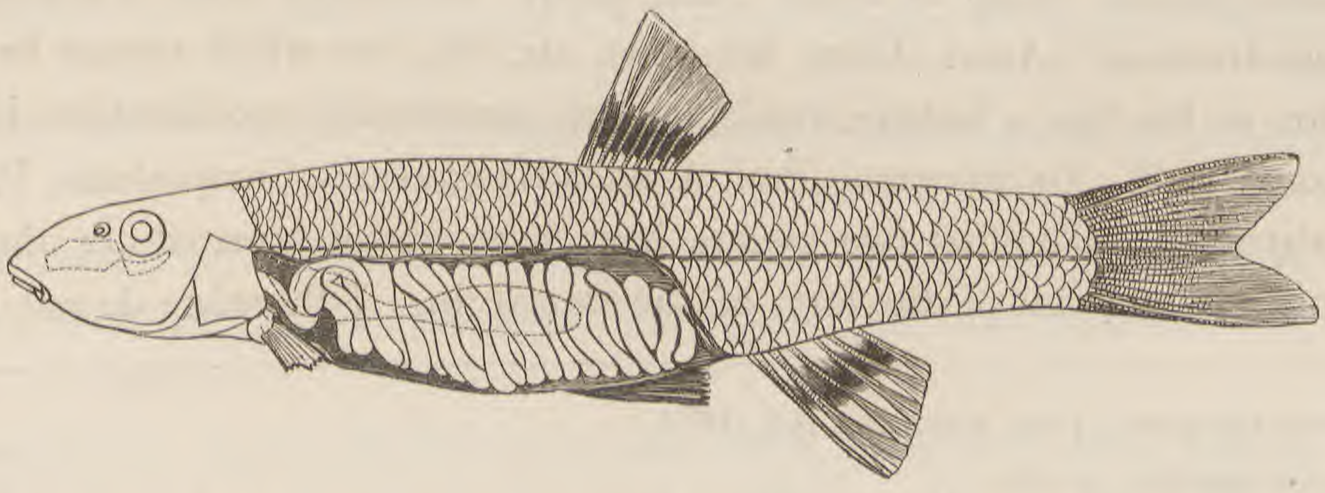
General color reddish, cheeks silvery. A darker shade along lateral line, and a black spot at the base of the tail.

In general features this species is allied to the Pimephales, the excessively broad obtuse muzzle, with tubercles in front, and small inferior mouth, giving it much the same physiognomy. The arrangement of the former is as follows:

There are two rows crossing the front of the muzzle; the inferior of six, of two on each side on the premaxillary border, and an outer near the eye; the superior of five, one on the middle line. A third row of four is on the border of the superior plane, one behind each pair of nares, and one on each side the middle line of the muzzle.

CAMPOSTOMA, *Agassiz.*

Amer. Journ. Sci. Arts, 1855. Girard, Proc. A. N. S. Phila., 1856, 170.



Species of this genus have as yet been only found in the tributaries of the Ohio, in our State. The known species are from the waters flowing into the Lakes, the Mississippi, and the Gulf. While it represents in our waters the Chondrostoma of Europe, as pointed out by Agassiz, the arrangement of the abdominal organs is now found to be so peculiar as to separate it more widely from the latter than has been hitherto accepted. This has been indicated above in the diagnosis of the tribe Mesocysti. Hybognathus indeed coincides more nearly with Chondrostoma, though it lacks the acute labial sheaths, but the palæotropical genus Gymnostomus, Heckel, affords an intermediate form of mouth. In

the palæarctic genus the alimentary canal attains 2.5 the length, in Hybognathus 4 times, while in Gymnostomus the length exceeds that of Campostoma, amounting to from 8 to 11 times the length (Heckel). But in these genera it is arranged as in Chrosomus and Stilbe, in a series of horizontal convolutions in no wise affecting the position of the natatory bladder. Indeed, in no other genus than Campostoma have I observed the latter organ involved in vertical coils of the intestines, and separated from contact with the abdominal walls. In C. dubium, sixteen coils may be counted from the side, each corresponding to an intercostal space; the intestine is eight and three-fifths length of head and body. In C. hippops it is a little shorter. The natatory bladder in both is much diminished in size, not extending behind the anterior two-thirds of the abdominal cavity. This is appropriate to the abode of the species, near the bottom, where they obtain their favorite vegetable food. In the more numerous species of carnivorous habit, that rise to seize insects on the surface, the bladder extends throughout the length of the abdomen.

A distinct though less degree of shortening is seen in the genera Gymnostomus and Hybognathus. Hybognathus nuchalis, Agassiz, the only known species of the genus, I have found to be abundant in the Wabash River, and Dr. William A. Hammond presented specimens to the Museum Academy Natural Sciences, from the Platte River, near Fort Riley, Kansas. Its digestive canal is longitudinally folded, exhibiting six flexures. The peritonæum is black.

The three epicystous genera above mentioned, and Acrocheilus,* Ag., of Pacific waters, form a homogeneous group of lesser rank, partly coinciding with Professor Agassiz' "Tribe Chondrostomi" (Amer. Journ. Sci. Arts, xix, 96), but which cannot be defined by the structure of the lips, a feature which presents considerable modifications in the genus Chondrostoma itself. To this group Prof. A. adds Exoglossum, Campostoma, Pimephales,† and Hyborhynchus. The first two genera have been already treated of; the two last I have separated on account of the form of the dorsal fin. I therefore do not believe any

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* See Gill on this genus, Proc. Acad. Nat. Sci., 1864.

† Pimephales agassizii, sp. nov.

Mouth short, terminal quite oblique, end of maxillary bone below nares, orbit one-fourth head 4.5 frontal width. Head equal, greatest depth 4.5 to origin of caudal. From latter to origin first dorsal ray less than from latter to end of muzzle. Scales narrowly exposed, 8-9—44—5; 29 rows anterior to dorsal fin; lateral line extending to below dorsal fin. Radii D. 18. A. 7. V. 8. C. 19. P. 16, tip $\frac{3}{5}$ to ventrals, latter to vent. Dorsal outline arched; front depressed behind line of nares. Total length 2 inches 11 lines; end muzzle to anal 1 inch 8 lines. Alimentary canal much complicated. Peritonæum with black pigment; above yellowish-olive, elsewhere dull silver; dorsal fin dusky, especially in a spot on anterior rays.

This species bears considerable resemblance to the P. milesii M., and the Hyborhynchus notatus Agass., and points to the identity of the two genera.

Habitat. A tributary of the Ohio at Richmond, Indiana. From a collection in Museum Academy, made by Elijah Coffin at that place.

trenchant division of the Cyprinidæ into the Phalacrognathi and Chilognathi, as has been proposed by Bleeker, exists in nature. Cochlognathus, Bd., Grd., which has also trenchant lips, is most allied to Hybopsis.

A species identical with Chondrostoma in dentition and other characters, is Leuciscus gardoneus, C. V., from South Carolina. Not having examined the splanchnology, I am unable to assign it definitely to that genus.

The description appended was taken from the types of Cuv. Val., in Paris.*

Species of this genus bear a strong analogical resemblance to such Ceratichthyes as C. biguttatus, in the small superior eye and decurved front, and especially during the breeding season, when the muzzle of the males is similarly swollen, and with the front and vertex ornamented with series of corneous tubercles.

The pharyngeal bones are characterized by the length of the superior limb; teeth straight.

The following is a synopsis of species known to the author:

Scales of lateral line 49—57.

Front elevated, diameter of eye near four times in depth of head; head 4.5 in length to caudal emargination; fins with median black band. End muzzle to origin dorsal longer than from latter to base of caudal; lip complete round mandible.

CALLIPTERYX.

Front plane, eye 2.5 in depth head; head 4.5 to 5 in length as above; eye 5.25 in head in adult; 3-5 in young of 3 in. End muzzle to first dorsal shorter than from latter to origin caudal. Lip not complete round mandible.

DUBIUM.

Front not elevated; eye 4.5 in head of young of 3 in.; head 5 in length as above; form of Semotilus.

GOBIONINUM.

Eye 5 times in head of young at 2.5 in. long; head, muzzle elongate decurved, 4.5 in length to notch of caudal.

MORMYRUS.

Of the above species Campostoma callipteryx was taken in the Flint River, Michigan (Proc. Acad., 1864, 284), and C. mormyrus and gobioninum from waters flowing into Lake St. Clair.

The C. anomalum, Agass. (*Rutilus anomalus*, Raf.), is stated by Prof. Agassiz to possess the dental formula 1.4—4.1; I have not yet met with it. He also states that the *Exoglos-*

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* Chondrostoma gardoneum, m. e. Cuv. Val., from South Carolina, Bosc.

Sp. w. smaller eye, large scales, short obtuse nose. Isthmus very small. Mouth small, edges of jaws cutting, the under received into the upper, canthus opposite middle of narial concavity, direction a little descending; no barbels. Teeth 5—5 w. broadish masticatory surface, two superior a little hooked, and stand on an upward and backward projecting crest of the bone. Ventral opposite or a little in front of dorsal, 8 r. Anal 1—9, C. 19, D. 1—10.

Scales 7—39—3. Eye four times in head, one and four-fifths in frontal breadth. Head five and one-half in total length, and one and one-half in height. Yellowish greenish-black, apparently a weak vertical streak on anal fin. Acute scale behind ventral.

sum spinicephalum, Val., is identical with it. The latter differs from the C. dubium in the more numerous scales of the lateral line.

CAMPOSTOMA DUBIUM, *Kirtland.*

Exoglossum dubium, *Kirtland*, Journ. Bost. Soc. Nat. Hist.



I have twenty-nine specimens of this fish before me from the Youghiogheny, Pa., the St. Josephs, Michigan, and the White River, Indiana (W. P. Clark), and find no variation except in the scales of the lateral line, which, while usually 49 to 52 in number, in two of the White River specimens reach 55 and 57.

In this species the suborbital bone is narrow and sickle-shaped; the premaxillary bones are protrusile, and overarched by a strong dermal fold. The upper lip is long, but the lower not completed round the arch of the mandible.

The general form of this fish is elongate, with a deep caudal peduncle, this depth measuring nearly half the length of the head. Greatest depth one-fifth length to caudal emargination. Pectorals extend two-thirds length to ventrals, latter just to vent. Anal narrow, first rays not longest, its basis little over half greatest length. Dorsal small immediately over ventrals, its basis 1.5 height; latter .33 in length from its first ray to origin of caudal.

The scales, as in Semotilus, are more equally exposed in young than adult individuals, where they become crowded anteriorly and less exposed; number 7-8—49-57—8-7; lateral line nearly straight, elevated shortly at its anterior extremity.

The muzzle is elongate, and contains twice the diameter of the eye, or 2.5 the internarial width from hinder nostril above, or 1.5 the interorbital width. Frontal bones convex. R. D. 1. 8, C. +19+, A. 1.7, V. 1.8, P. 16.

Length 5 inches.

In adults the dorsal, caudal, and anal fins have a black median band. In spring the smaller specimens have the inferior fins and the caudal light orange without markings. General color, above leaden, below cream color with leaden tinge. The peritonæum of this species is black.

The Campostoma is a fish of comparatively slow movements, and readily takes a hook baited with a worm. It occurs in clear and calm waters, but is probably not averse to mud.

In completion of this synopsis, it is necessary to add two species of the family which have been introduced, the Cyprinus carpio, from Europe, and the Carassius auratus, or gold fish, from China, by way of Europe. Each represents a distinct group of the Epicysti preceding our Group I, with the following characters:

Group O. Barbels present; teeth of the molar type, with grooved crown, more than one-rowed. Alimentary canal elongate. Dorsal fin much elongate.

Teeth 1.1.3—3.1.1; both lateral and angular beards. Dorsal and anal fins with strong spines; basis of latter short. CYPRINUS.

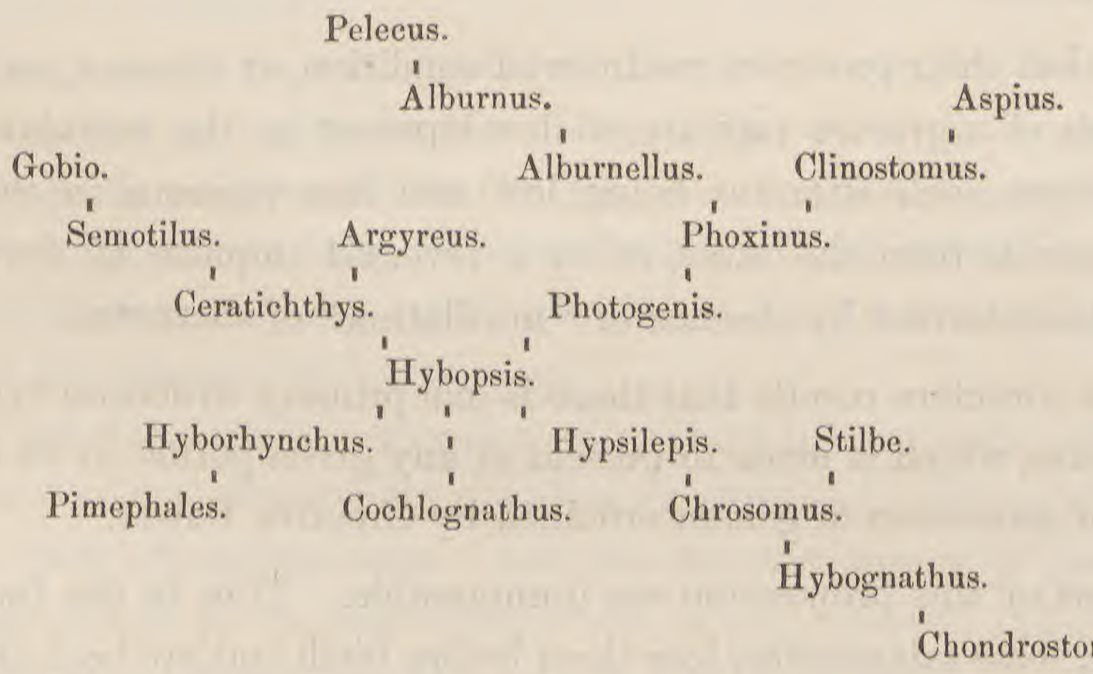
Group OO. Barbels none; teeth broad, flat, truncate, scalpriform, one-rowed; dorsal fin with elongate basis. Alimentary canal elongate.

Teeth 4—4; dorsal and anal with strong osseous spine; latter with short basis. Mouth terminal. CARASSIUS.

The carp is olivaceous, the gold fish varies from olivaceous to black, silvery, and crimson. Both are taken in the Schuylkill, the Carassius much the more abundantly, as I have witnessed, as far as Conshohocken, sixteen miles above Philadelphia; the latter fish occurs no doubt much higher up this river.

The crania of these, and of all other genera of Cyprinidæ, in individuals of all ages, I have found to be fully developed, while among Catostomidæ, as Catostomus (*Hylomyzon* and *Ptychostomus*) and Carpiodes, its superior wall is interrupted by a longitudinal fontanelle. In the genus Cycleptus, however, the cranium is as complete as in the Cyprinidæ. It may also be observed as characteristic of the two families, that in the latter the masticatory table of the basi-occipital occupies only the basal portion of the basi-occipital ensiform process, while in Catostomus the latter is entirely covered by a broad cordiform table, which is largely lacunary and not solid.

The characters of our genera of Epicysti, having been already given, their serial affinities may be usefully presented in the following form:



In connection with future study of this and other types of organized beings, the following observations on the probable law of evolution of types are appended.

In the present state of our knowledge, we believe the following laws can be established:

I. That genera form series indicated by successional differences of structural character, so that one extreme of such series is very different from the other, by the regular addition or subtraction of characters, step by step.*

II. That one extreme of such series is a more generalized type, nearly approaching in characters the corresponding extreme of other series.

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* St. Hilaire, Owen, Agassiz.

II. That the other extreme of such series is excessively modified and specialized, and so diverging from all other forms, as to admit of no type of form beyond it.*

IV. That the peculiarities presented by such extremes are either only in part or not at all of the nature of adaptations to the external life of the type.†

V. That rudimental organs are undeveloped or degraded conditions of the respective characters developed or obliterated in the extreme of the series.

VI. That therefore the differences between genera of the same *natural* series are only in those characters which characterize the extreme of that series.

VII. That the relations of the genera of a series are those of the different steps in the development of the individuals of the extreme genus *ab ovo* (*Von Baer*, *Agassiz*), (with sometimes the addition of special adaptive features ? ?).

VIII. That a natural (*i. e.* trenchant) genus is distinguished from its nearest affines by but few characters.

IX. And that their presence, rudimental condition, or absence, can be accounted for on the hypothesis of a greater rapidity of development in the individuals of the species of the extreme type, such stimulus being less and less vigorous in the individuals of the types as we recede from the same, or by a reversed impulse of development, where the extreme is characterized by absence or "mutilation" of characters.

X. That it therefore results that there is one primary structural type involved in such a series of species, which is made to present at any given period in its Geologic history that appearance of succession of genera ordained by Creative Power.

Illustrations of this proposition are innumerable. Thus in the important character of the branchiæ, some salamanders lose them before birth and are born alive; other viviparous species maintain them for a short time after birth; some are produced from the egg, but lose them very shortly after birth, without employing them functionally; others use them during a very short aquatic life, some maintain them longer, and some to adult age; finally, some Amblystomata reproduce while carrying branchiæ, thus transmitting this feature to their offspring as an adult character.

In both Perissodactylous and Artiodactylous Mammalia, certain types develop their family character of canines at the earliest appearance of dentition, others not till a comparatively late period of life (Equus), and the extreme genera never produce them.

Among Cetaceans the genus Orca maintains a powerful and permanent series of teeth;

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* Leconte. Dana on Cephalization.

† Owen on Cetacea, Trans. Zool. Soc. Lond., 1866, 44. Leconte on Carabidæ, Trans. Amer. Philos. Soc., 1853, 364.

in Beluga the series is shed in old age, in Globiocephalus or the Caing whales they are shed at middle age, while in the Balænidæ, of which the absence of teeth is an essential character, these organs are developed, and absorbed *during fœtal life* (Eschricht).

It is well known that the Cervidæ of the Old World develop a basal snag of the antler at the third year; a majority of those of the New World (genera Cariacus, Subulo), never develop it except in "abnormal" cases in extreme old age of the most northern Cariacus (C. virginicus); while the South American Subulo retains to adult age, the simple horn of the second year of Cervus.

Among the higher Cervidæ, Rusa, and Axis never assume characters beyond an equivalent of the fourth year of Cervus. In Dama the characters are on the other hand assumed more rapidly than in Cervus, its third year corresponding to the fourth of the latter, and the development in after years of a broad plate of bone, with points, being substituted for the addition of the corresponding snags.

Returning to the American deer, we have Blastocerus, whose antlers are identical with those of the fourth year of Cariacus.*

In the important character of the scutellation of the tarsi among the Passerine birds, the "boot" appears early in life in the highest Oscines, later in the lower, and does not appear at all in the majority. In respect to the still more important feature of the long posterior plates which appear very early in most Oscines, in the Myiadestes type they appear late, the squamæ remaining long, while the Clamatores never develop the plates, not advancing beyond the infantile squamous stage.

In reviewing these and many similar examples everywhere coming under the eye of the naturalist, it is easy to perceive what would constitute a *plastic* and what a *conserved* condition of generic, or even of specific form. Let the development of a special feature be postponed to a later period of the individual's life, so that nature's intention be but feebly indicated at the period of reproduction, and that feature will be but feebly represented in the offspring.

That every series of forms has had its period of great multiplication, or its "protean," and thus probably plastic stage, is familiar to the student of palæontology. At other times than these a *vis conservatrix* would seem to insure a nearly entire permanency of generic form.

The above *law of retardation and acceleration* is, however, only proposed as a partial explanation of the *mode* in which the progress may have occurred; the grand law of what has determined or projected the *series* of genera to its extreme remains untouched. That it could have been a natural selection, resulting from favorable or hostile relations of surrounding conditions, is contradicted by the facts on which Prop. IV is based.

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* *Vide* the Illustrations of Cuvier's Ossemens Fossiles.

SUPPLEMENT

ON SOME NEW SPECIES OF AMERICAN AND AFRICAN FISHES.

Apogonichthys stellatus.

Scales 7—23; radial formula, D. vii, I. 9; A. II. 8; P. 10. Ventral with elongate rays extending beyond last anal ray. Caudalis rounded. End of maxillary nearly to opposite posterior margin of large orbit. A delicate frontal carina. Greatest depth three times to base of caudalis. End of muzzle truncate, with emargination to receive tubercle of mandible. Total length 1 inch, 7.5 lines; head 7.5 lines.

Reddish-brown, with a series of dark brown spots on the edges of the scales of each row (except that bearing the lateral line), each with a silver centre; head with numerous silver-centred brown spots. Caudal, dorsal, and anal fins dark, with dusky crossbars.

Two specimens, Mus. Academy, procured by Prof. Horatio C. Wood, Jr., at Nassau, Bahama Islands.

This is the second species of the genus now known to inhabit American waters. The previously ascertained A. americanus, Castelnau, was obtained at Bahia, but has been discovered by Samuel Powell, member of the Academy, at Newport, R. I.

Etheostoma macrocephalum, *Cope.*

This species is well characterized by its elongate anguilla-like cranium, and small scales. It may be compared with the other species of the genus as follows:

E. peltatum, Stauffer, Proceedings Academy Nat. Sci., 1864.

Orbit equal length muzzle; depth at first ray second dorsal 5.75 in total length to origin caudal.

Scales 6—53—8, a few on opercle; those of abdominal series five times size of others. Radii D. XII. 13. A. II. 9.

E. blennioides, Rafinesque, Kirtland, Bost. Journ. Nat. H., vol. III.

Orbit equal length muzzle; depth to length (as above) 1 : 6.5.

Scales 8—62—13-14; some on operculum; those of middle line below twice size of others or wanting. Radii D. XV (XIV) 12 (13). A. II. 9.

E. macrocephalum, Cope.

Orbit much less than length muzzle; depth (as above) 7 times in length to origin caudal.

Scales 11—77—15, none on opercle; those of ventral line twice size of others. Radii D. XV. 13: A. II. 11; orbit four and a half times in head to apex of opercular spine. Interorbital width one-fourth length from end of muzzle to line of transverse measurement. End of os maxillare falls opposite anterior rim of orbit. Anterior to dorsal fin scaleless; abdomen entirely scaled. Basis of anal less than that of second dorsal by two rays, and an interspace of latter. Length head 3.5 to basis of caudal fin. Anterior to ventral fins entirely smooth.

Total length 2 in. 10 lin., ditto from end muzzle to origin first dorsal, ten lines; to origin second dorsal (well separated from the first) 1 in. 7 lin.

Above light brown, with a slightly undulating whitish band extending from superior opercular angle to superior surface of caudal peduncle; dorsal line marked by darker quadrate spots, with marked light interspaces. Lateral line and several rows of scales above and below, marked by nine blackish longitudinal spots with smaller ones alternating. A blackish band on muzzle to orbit. Head and body below straw color, except a narrow black line directed backwards below the pupil and cheek on the mandibular ramus. First dorsal with a median series of vertical black lines; second dorsal with three, caudal with four, and anal with a basal transverse black bar. Head spotted above.

Habitat. Three specimens of this Percid are in the Museum Academy Natural Sciences, procured by myself in the Youghiogheny River, Pennsylvania, with Pleurolepis pellucidus, Baird, Catonotus flabellatus, Rafinesque, and other interesting species. They occur in stony parts of the river, and are a graceful and active, as well as delicately colored species when living. The feature, apparently important, of a median abdominal series of spinous shields in the genus Etheostoma (noticed only before Stauffer by Girard, in the E. maculatum, *Alvordius maculatus*, Girard), is not present in a half-grown individual of the E. macrocephalum, the middle line of the abdomen being scaleless. In an E. blennioides, from the Kiskiminitas, Penna., of 34 lines in length, the shields are distinct, while in another of 30 lines, from Richmond, Indiana (obtained by Elijah Coffin), the same region is naked. These are probably a periodical development, appearing in the breeding season, like the corneous excrescences of the Cyprinidæ. They are appropriate defences to these fishes which lie or move upon rocky bottoms, and are unable to suspend themselves in the fluid medium for a length of time.

Cryptosmilia luna, *Cope*, gen. et sp. nov.

Char. gen. Fam. Chætodontidæ, affined to Drepane. No vomerine or palatine teeth; several long sharp spines on the inferior margin of the præoperculum. Dorsal fin with a deep concavity in front of the articulated portion, spinous portion not squamous, with ten

rays, of which the anterior is small and directed downwards and forwards. Anal with three spinous rays, its whole extent equal that of the soft dorsal. Branchiostegal radii six. Pectoral fin elongate.

Char. specif. Greatest depth of body between origins of dorsal and anal fins equal length of body from end muzzle to origin of caudal fin. Radii D. X. 21. C. +18+. A. III. 17. V. I. 5. P. I. 16. Osseous ray of pectoral very small; that of ventral very strong. Soft rays of ventral reaching to soft anal; ditto of pectoral to origin of caudal. Caudal angularly convex. Second and third spinous dorsals small, fifth much the longest.

Scales 11—43—27; lateral line describing a strong upward curve. Cheek and a patch on the branchiostegal membrane scaled. Orbit twice in length of head, two and one-half times in vertical line below superciliary ridge. Operculum narrower than scapular plate, with suboperculum over three times as high as wide; latter ascending to opposite inferior margin pupil. Præoperculum serrate behind and with nine cutting spines below. Mouth very small, projectile; teeth in numerous packed series, simple, acute.

Color. Everywhere uniform silvery.

Dimensions. Total length five in. six lin. Depth four in. one lin. From gular region to point of supraoccipital crest two in. six lin. Depth of soft dorsal and anal fins respectively one in. one lin., and one in. Height of fifth dorsal spine one in.

Habitat. Western African seas. Sent to the Academy by our correspondent, Dr. Thos. S. Savage.

This interesting type represents in its range, the Drepane of East Indian seas. Its peculiarity consists in its stronger armature, and increased number of dorsal rays.

Corvina monacantha, sp. nov.

A species differing from those hitherto described, in having one anal spine, no pseudobranchiæ, and more numerous dorsal rays. The pseudobranchiæ are ? wanting (Günther), in C. microps, Steindachner, and in some others, the first anal bony ray is very short.

The greatest depth (at front of dorsal fin) equals length of head; præoperculum sharply serrate on vertical margin.

Scales 10—16—49 at ventrals; lateral line continued to end of sublanceolate caudal. Diameter of eye one-fifth head. Pharyngeal patches small; teeth bristly. D. 10. 1. 33. C. 17 A. 1, 5; V. I. 5, first articulate prolonged into a filament, which reaches beyond vent; P. 18 as long as tip ventrals without filament. Silvery everywhere, without spots; dorsal region grayish.

Total length 8 in. 6 lin.; end muzzle to base of caudal 6.75 in.; same to base of anal 4.5; same to base of pectoral 2.2.

Habitat. Near Parimaribo, Dutch Guiana. Dr. Hering, Mus. Academy Nat. Sciences.

Chirostoma beryllinum, sp. nov.

Form of body shorter than usual; posterior margin of first dorsal far in advance of second dorsal, and just in front of opposite first anal ray; last anal a little behind last ray of second dorsal; tips of ventrals opposite first ray of first dorsal. Head 4.25 times to base of caudal. Orbit large, one-third head; mouth small, mandible slightly longer, curve forming a quadrant. Greatest depth (in front of anal) six times in length to basis of caudal.

Scales large, ten longitudinal, thirty-six transverse rows; lateral line represented by a pore on the anterior part of the posterior field of each scale, except on the caudal peduncle, where there is a groove. The anterior separated portion of the line is on two adjacent series of 5—4 scales each. Radial formula D. V, last well developed; I. 11. C. 17, deeply furcate; A. I. 18; V. I. 5, four interior twice furcate; P. 15 acuminate.

Total length 2.5 inches; end muzzle to base of first dorsal 1.06 inches.

Color. Bright pale olive, a silver band from axilla to caudal on two half rows of scales, leaden margined above; basis of anal leaden. Sides of head silvery.

Habitat. The only specimen I possess of this species I procured in the Potomac River, at Washington, D. C.

Gobius dolichocephalus.

Intermediate between G. banana, C. V., and G. mexicanus, Gthr. Radial formula D. 6—11, A. 1—10.

Scales 68 in lateral line, 21 rows between second dorsal and anal; those in front of dorsal fin minute; head entirely naked. Caudal fin rounded, not elongate, one-sixth of length. No canine teeth. Interorbital width equal diameter of eye, which enters head 5.5 times, and enters 2.2 in muzzle. End of maxilla opposite anterior margin of orbit. Ventrals shorter than pectorals, falling far short of vent, with broad anterior connecting membrane. Breadth of head greater than depth, and more than half length of head; depth of body one-sixth of total. Yellow olive above, with black marbling on the sides. Spot at upper origin of pectoral, and upper angle operculum; top of muzzle and edge of lip black. First dorsal faintly, caudal strongly barred with black; second dorsal with rows of black spots on each ray. Fins and surface below, yellowish.

Habitat. Near Orizava, Vera Cruz. Prof. Sumichrast, Mus. Academy and Smithsonian.

The differences between this species and the mexicanus result from the greater shortness of the body in the former, increased width of head, and small size of eye. To our measurements are appended those of the latter, taken from Günther's "Catalogue":

	G. dolichocephalus.	*G. mexicanus.*
	in. lin.	in. lin.
Total length,	7 0	8 0
Height of body,	1 0	1 1
Length of head,	1 7	1 8
Greatest width of head,	1 0	0 11
Diameter of eye,	0 3.25	0 2.5
Length of caudal fin,	1 1.5	1 0

Ageniosus porphyreus.

Head three and two-thirds in length to origin of caudal, covered on the occiput with smooth skin. Eye its own diameter behind rictus oris. Maxillary barbel concealed, not attaining rictus by its length. Pectoral fins not attaining ventrals; the spine acute, smooth behind, three and one-third times in length of head. Ventrals falling far short of anals; caudal deeply forked. Dorsal spine slender, flexible, rugose in front; formula D. 1.7. C+18+. A. 44; V. 7. P. 15.

Color. Back and narrow extension on sides, with nape and top of head, brown purple, irregularly marbled throughout the length with the silvery of the sides, which is prolonged anteriorly as a band to the occiput. An eye-like spot between gill opening and dorsal fin on each side. Side of head and below yellowish.

Habitat. Surinam. Dr. Charles Hering, Mus. Academy Nat. Sciences.

This fifth species of the genus is allied to Kner's A. dentatus, from near Para.

Pimelodus (Rhamdia) brachypterus.

D. 1.6 A. 11. P. I. 9. Adipose fin about equal from its anterior extremity to origin of first dorsal ray, three and two-thirds times in length from end of muzzle to base of caudal. Occipital process short. Maxillary barbels to beyond first dorsal, external mandibular to axilla. Height of body at anal fin equal same at first dorsal, five and one-third times to base of caudal; length of head five and two-thirds in same. Greatest width of head three-fourths its length. Mandible a little shorter, intermaxillary band one-fifth as long as broad. Eye nearer extremity muzzle than to opercular border, diameter nearly half

frontal width. Dorsal fin longer than high, spine very weak. Pectoral spine striate distally, flexible, strongly serrate on inner margin. Anal laid backwards, reaches line of adipose. Caudal deeply emarginate, lobes narrowly rounded, one-eighth total length. Operculum and occipital region radiate grooved.

Above blackish, below silvery, a light shade across middle of dorsal fin.

This species differs from its ally, P. motaguensis, of Guatemala, in its smaller eye, much deeper body, and slight differences in the radial formula.

From Orizava, Mexico. Prof. F. Sumichrast, Mus. Academy, Smithsonian.

Engraulis duodecim, sp. nov.

This fish was taken at Beesley's Point, New Jersey, by our late fellow member, Samuel Ashmead, and by him presented to the Academy. It differs from both the E. vittatus and E. brownii in having the dorsal fin entirely anterior to the anterior ray of the long and deeply concave anal, and in the serration of its belly.

Scales with twelve transverse undulate grooves, large, in eight longitudinal, and thirty-four transverse rows. Greatest depth in front of dorsal, one-fourth length to base of caudal; length of head three and two-thirds in same. Middle pupil marking less than one-third distance from end muzzle to end maxillary; eye 4.5 in head. Pectorals reaching ventrals, r. 12; ventrals not attaining vent, r. 7; anal 1.27; caudal deeply forked. Total length 3.87 inches; end muzzle to base dorsal (straight) 1.625 inches; rays of latter 1.12, the anterior five times the height of the posterior.

Iridescent silvery, dorsal region pale brownish (in spirits).

Enteromius potamogalis, *Cope*, gen. et sp. nov.

Char. gen. That of Labeobarbus, with the peculiarity of short alimentary canal, equal the length of the head and body, and of articulated second dorsal ray instead of a spinous one. Pharyngeal teeth with very shallow concavities.

This genus therefore combines general features of Gobio with the dentition of Labeobarbus.

Char. specif. Form compressed and gibbous. Inferior limb of pharyngeal bones two-thirds length of superior, a slight external angle; teeth 2.3.5—5.3.2, the inferior of the longer row very small and conic. Radii D. I. 9. C. +19+. A. II. 6. V. I. 8. P. 15. First long dorsal ray weak as the last, and not a spine, hence counted with the branched rays. Ventrals not attaining vent, but reached by the acuminate pectorals. Orbit four times in head, diameter less than length of muzzle, latter rather broad. Outline steeply descending

from front of dorsal fin. Head 4.2 in length to origin of caudal; four well-developed barbels. Greatest depth three times in length to origin caudal.

Scales large, minutely granular, with few (5–8) and coarse radii, 4—22-3—2-3. Several rows extend over the basal third of the caudal fin. Total length 4 inches 9 lines; to origin dorsal (oblique) 10.5 lines; to origin anal 2 inches 9 lines. Lateral line little deflexed.

Coloration. A broad, straight, dark brown band from end muzzle to origin caudal fin, which is light and dark margined above. Above dark cinnamon brown, each scale silvered; below paler brown, each scale with a deep brown spot at base; tip of dorsal fin brown.

The anterior tract of the alimentary canal falls a considerable distance short of the vent, while the second flexure is produced to the anterior extremity of the abdominal cavity, being slightly prolonged to one side. The distal portion is slender. Among the ingesta were found remains of crustaceans.

The natatory bladder extends to the posterior extremity of the abdominal cavity.

Habitat. This species was procured by the African traveller, P. B. Duchaillu, in streams and rivulets fifty to sixty miles north of the equator, and the same distance from the ocean.

Labeobarbus aureus, *Cope.*

Pharyngeal bones without external angle, inferior limb from tooth series a little shorter than superior from other extremity of same; teeth 2.3.5—5.3.2.

Scales 5—37—2, lateral line decurved, rising at front of anal fin. Rays D. II. 8. C. +19+. A. II. 6. V. II. 9. P. 18. Second dorsal spine slender, terminal third articulated; pectorals not reaching ventrals; latter falling short of vent, having elongate scute in axilla, and median plate below; anal appressed, extending two-thirds distance to vent. Outline arched from dorsal, muzzle depressed, projecting; four well-developed barbels. Eye one and two-fifths times in muzzle, four times in head; latter 3.8 times to origin caudal. Greatest depth 3.75 in same. Above, to second row above lateral line, brownish olivaceous; below this point and on sides of head, golden.

Length to end caudal 9 inches; to base of dorsal 3 inches 6 lines; to origin anal 5 inches 5 lines.

Habitat. Two specimens of this species were sent to the Academy by our correspondent, Dr. Alden Grout, from the Umvoti Mission, near the boundary between Zulu Land and Natal, South Africa. The species is nearest the L. mariquensis, Smith, of Central South Africa.

Sphagomorus erumei, gen. nov.

Hippoglossus erumei, Cuv. *Psettodes erumei*, Gthr.

This East Indian species has been assigned by Dr. Günther (Catalogue) to Bennett's genus, *Psettodes* (Proc. Comm. Zool. Soc., London, 1831, 147), and the West African P. belcheri, Benn., identified with it, with doubt. The Academy Natural Sciences having received from our correspondent, Dr. Thomas Savage, a fine specimen of Psettodes belcheri, from the coast of West Africa, I am able to ascertain its generic distinctness from the above mentioned East Indian form, although, as in the case of Drepane and Cryptosmilia, the two are surprisingly similar. The genera differ as follows:

Sphagomorus, Milei.	*Psettodes*, Benn.
Maxillary and mandibular teeth simple.	Maxillary and mandibular teeth with sagittiform or barbed point.
Vent between the ventral fins.	Vent much behind the ventral fins.

The S. erumei has the jaws smooth; they are scaled in the P. belcheri; the lateral line is slightly oblique anteriorly in the latter, in the former distinctly arched. In P. belcheri the caudal fin is scaled to near the tip; the form of the body is less elevated than in Richardson's figure of the erumei (Voyage Sulphur). The scales of the lateral line, radial formulæ, and coloration, are identical with those of the Sphagomorus.

SUPPLEMENTARY SYNOPSIS

OF THE ESOCES OF MIDDLE NORTH AMERICA.

Six species of Esox, inhabiting our waters may be defined as follows. Others have been described, but in such a way as to leave it doubtful whether they really exist. Girard has pointed out the differences in squamation of the head, and the author has given a synopsis of the species,* which, however, possesses many defects, owing to the inclusion of species on the basis of imperfect published diagnoses.

I. Operculum and cheek entirely scaled.

Branchiostegal rays 12—13 (14); front grooved. Dorsal radii 2.12—14.

End of muzzle to pectoral fin shorter than from ventral to pectoral; same to orbit less than from orbit to margin operculum; scales between ventrals and pectorals larger, 37 rows. FASCIATUS.

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* Proceedings Academy Natural Sciences, 1865, 79.

End of muzzle to pectoral longer than from pectoral to ventral; same to orbit less than from orbit to opercular margin; scales between ventrals and pectorals small, 44–50 rows. POROSUS.

End of muzzle to pectoral longer than from pectoral to ventral; same to orbit equal from orbit to opercular margin; scales between ventrals very small, 52–57 rows. UMBROSUS.

Br. R. 14—16.

Dorsal outline straight; pectoral fin nearer ventral than end of muzzle. D. 18. A. 17. Depth six times to base of caudal. End of muzzle to orbit equal from orbit to opercular border or beyond. RETICULATUS.

D. 22. A. 21. Probably, not certainly, in this section. DEPRANDUS.

II. Cheek entirely, operculum half, scaled.

Dorsal outline horizontal; pectoral nearer end of muzzle than to ventral. B. 14—15. D. 19. End of muzzle to orbit equal from orbit to border of operculum. Frontal groove deep. LUCIUS.

III. Cheek and operculum half scaled.

B. 19. D. 19. No front groove. NOBILIOR.

ESOX FASCIATUS, *Dekay*, Geol. Surv. N. York.

E. ornatus, Girard, Pr. Bost. Soc. N. H. Storer, Amer. Acad. Arts, Sci., Tab. xxiv, Fig. 2.

Besides the characters above pointed out, this species possesses the following:

Anal radii 4.11—12; scales 12—13 (below dorsal) 92—107 l. l. 11—13 (above ventral). Br. R. 12—13. From basis of caudalis to opposite first ray of dorsalis three times to the preoperculum, or a short distance in advance of it. Head three and one-half times to end of caudal fin. Eight rows of scales on the cheek.

The stout form and large thoracic scales of this species are well indicated in Storer's excellent figure. The colors are very dark, and become bars directed forwards on the inferior lateral region.

Length of adult 10 inches; greatest depth 1.375 inches.

Five specimens of this species are in the Museum of the Academy, three of them adult, procured in Long Island, N. Y., through the kindness of my friend Thomas Bland, of Brooklyn. They present no variations.

ESOX POROSUS, *Cope.*

Esox cypho, Cope, Proc. Academy Natural Sciences, 1865, 78.

The additional characters of this species, in which it will be observed it is quite identical with the preceding, are:

Radii, branchiost. 12—13; anal 3.12. Scales 11, 109—113, 12. Basis of caudalis to

basis of first dorsal ray three times to margin of præoperculum, or a short distance in front of it.

Var. A. All the abdominal, and most of the lateral scales give vent to a tube like those of the lateral line, at the bottom of a deep emargination. The head is contained four times in the length to the end of the caudal fin. Color, with broad brown bars directed obliquely forwards on the sides, or more numerous narrow black lines.

Of this variety there are numerous specimens in Museum Academy, from the neighborhood of Philadelphia, from Darby Creek, and the black lined form from White Clay Creek, Chester County, procured by my friend Vincent Barnard, of Kennett Square. It does not inhabit the running waters, but may be seen at any time in the "cut offs" and pools or dams, under the shelter of the broad leaves of the Nuphar advena, or among the Pontederias and Potamogetons. It will seek out such situations through the most insignificant outlets and rills, where it would seem to be in constant danger of having its retreat cut off. It does not attain a large size.

Var. B. Few or no tube-bearing scales, except those of the lateral line; abdominals entire; length of head three and one-half times in length to end of caudal. Broad oblique lateral bars.

Four specimens from Michigan, described formerly as *E. cypho*, and only differing from Eastern specimens as above. I have thought best to erase the name *cypho* (hunchback), as the feature it expresses is probably to a considerable extent the result of distortion.

ESOX UMBROSUS, *Kirtland.*

Cleveland Annals Science, 1854, p. 79. *Esox?* Cope, Pr. A. N. Sci. Phila., 1865, 79 (Grosse Isle).

In addition to characters given above, this species possesses the following:

Branchiosteg. radii 12—14; anal 2—3. 12; scales 12—15, 113—122, 13—15. Ten to twelve rows of scales on the cheek.

Var. A. From basis caudal to opposite basis dorsal three times to between præoperculum and orbit, or to between posterior margins of orbits (in specimens from Richmond, Indiana); brown bars on the sides directed forwards below.

Three specimens, one from Grosse Isle, near Detroit, one from Michigan City, Ia.

This variety, or the preceding species, may be that referred to by Prof. Kirtland as the *E. fasciatus*, found in Ohio.

Var. B. From basis caudal to opposite first dorsal ray three times in length to anterior

margin of orbit, hence with longer caudal peduncle than any of the preceding species and varieties. Color uniform leaden, without bars or spots. Length 10 in., depth 1.5 in.

Two specimens from the Susquehanna, procured by Jacob Stauffer, Sec. Linnæan Society, Lancaster. This may be typical of the E. umbrosus, as Prof. Kirtland does not represent any lateral bars; nevertheless, it cannot be decided from his description.

In the three preceding species the band of vomerine teeth is nearly equal in length to the palatine, sometimes a little longer, sometimes a little shorter.

ESOX RETICULATUS, *Leseuer*.

The common pike of the large Eastern Atlantic coast streams; not known from the interior. Well figured by Storer, l. c.

ESOX DEPRANDUS, *Leseuer*, Cuvier and Valenciennes, N. H. Poissons.

Not observed since Leseuer's time; from the Wabash.

ESOX LUCIUS, *Linnæus*, Cuvier, Richardson. Cope, Proc. Acad., 1865, 79. *Esox estor*, Leseuer, Journ. Acad. I, p. 413.

The Great Lakes; Lake Whittlesey, Minnesota; John H. Slack, M.D.

ESOX NOBILIOR, *Thompson*.

Hist. Vermont, and Proc. Bost. Soc. N. H., 1850, 305, where this is rightly stated to be the *estor* of Richardson. It is also evidently *estor*, Agassiz, Am. Journ. Sci. Arts, xvi, p. 308, and formerly of Kirtland, but later correctly named by the latter, Cleveland Annals of Science, 1854, p. 78; also *E. lucioides*, Agass. and Gir., in Frank Forester, by Herbert. Fine specimens from Saginaw Bay, No. 228. A specimen is in the Academy Museum from the Alleghany River, in Warren Co., Pa., and another was presented by Thaddeus Norris, from Conеaught Lake, Crawford Co., Pa. The head of the latter measures 12 in. 9 lin. in length, and 17.6 in circumference at the preopercles.

General habitat. The Great Lakes, River St. Lawrence, and Lake Champlain.

ARTICLE XIV.

ON SPECIES OF FOSSIL PLANTS FROM THE TERTIARY OF THE STATE OF MISSISSIPPI.

BY LEO LESQUEREUX.

With Ten Plates.

The specimens of fossil plants described and figured in this memoir were collected and sent to me for examination, a few years ago, by Prof. Eug. W. Hilgard, State Geologist of Mississippi. A short account of these plants has been already published in the first volume of his Report.* The examination was then commenced, and has been interrupted and put aside until now, by unforeseen circumstances.

These remains of leaves are mostly preserved in a kind of hard, red, ferruginous, more or less laminated shale. A few of them are imbedded in a soft whitish clay; some others in a darker yellowish coarser clay, and one species in a coarse brown sandstone. As the geological and geographical distribution of the deposits where these plants have been found will be examined hereafter, I have merely indicated, after the description of each species, the color of the stone with which it is connected.

1. Calamopsis Danai, *Lesqx.* Pl. xiv, Fig. 1, 2, 3. C. foliis magnis, frondosis, pinnatis; pinnis gramineis, planis, oppositis, æquidistantibus, basi subattenuatis; nervis primariis 3–5 æqualibus, secundariis unicis, gracilioribus, lineales areas dividentibus, nervulis minimis, parallelibus, approximatis, notatas.

Yellow coarse clay.

A figure of this beautiful palm is given by Prof. Jas. D. Dana in his Manual of Geology, page 513, Fig. 95. The leaflets or pinnæ are somewhat narrowed at the base, as seen in Fig. 2. In Fig. 1, they seem to be slightly decurrent on the rachis, an appearance due to some deformation by the process of petrification. These leaflets are ribbon-like, and it seems, pretty long. Near the base of the frond they are about one inch broad, with five to seven primary nerves, while in the upper part their breadth is but one-fourth of an inch, marked only by three to five primary nerves. The spaces or areas between these nerves are divided in the middle by a secondary vein, less marked than the primary ones,

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* Report on the Geology and Agriculture of the State of Mississippi, by Eug. W. Hilgard, Pr. D. (1860), pages 108, 109, &c.

and between these, there are still three to five very fine veinlets, thus forming a tricompound, parallel nervation. The rachis is proportionally narrow, about one-fourth of an inch broad, and is narrowly furrowed in the middle.

The only fossil plant known as being evidently related to this species is *Calamopsis Bredana*, Heer, Flor. Helvet. Tert. III, p. 169, Pl. cxlix, from Œningen. It differs essentially from the American plant by its nervation, which is only a compound of two kinds of veins, and by its narrow leaflets, which are placed somewhat in pairs. The European species has, like ours, the ribbon-like leaflets narrowed at the base, appearing also, from the figures, sometimes slightly decurrent.

This plant is referable to the Palm family; but no living species is known, which can be compared to it.

2. SABAL GRAYANA, *Spec. nov.* Pl. xiv, Fig. 4, 5, 6. S. fronde petiolata, rachide in plano posteriore subplana, e basi dilatata ovata, lineari cuspidata 6–8 policari; foliis flabelliformibus, radiis numerosis, elongatis, sensim dilatatis, nervulis distantibus, gracilimis.

Soft white clay.

The specimens figured indicate the form of a whole leaf. The rachis contracted just at its base, is abruptly enlarged above and then tapers upwards into a long linear point. The rays, about one-eighth of an inch broad near their point of union to the rachis, gradually enlarge upwards. Fig. 6 shows them to be already one inch; on some broken pieces of specimens they are two inches broad. Though the nervation is distinct, the veinlets are not strongly marked, and they are rather at a distance from each other, their number varying from five to ten, according to the breadth of the rays. This greater distance of the thinner veinlets, the peculiar contraction of the base of the rachis, and the broader rays, are the only appreciable characters which separate this species from *Sabal major*, Heer, a fossil plant whose remains are abundant in the Miocene of Europe. Small fragments of a species indescribable, but evidently different from this one, have been collected at Nanaimo, Vancouver's Island, by Dr. John Evans.

3. SALISBURIA BINERVATA, *Spec. nov.* Pl. xv, Fig. 3 to 6. S. foliis subquadratis, polymorphis, e basi rotundata abrupte attenuatis, superne dilatatis, truncatis, lobatis vel lacerato-divisis, margine undulatis; nervis primariis binis, angulo vario e basi divergentibus, secundariis e primariis sub angulo acuto egredientibus, dichotomis.

Red shale.

It is not easy to get an idea of the true form of this species from the mere fragments which have been found. Evidently these leaves were polymorphous, as they are now in the living species of *Salisburia*. They were apparently about square, with a round decurrent base, the sides undulate and the upper part truncate and cut in irregular divisions. The nervation of these leaves is peculiar. Two distinct primary nerves diverge from the

base, and the secondary nerves come out of them and fork in ascending, being generally straight in the middle part of the leaves, and arched on both sides, a nervation somewhat similar to that of some *Cyclopteris* of the coal measures. In *Salisburia adiantifolia*, Smith, from Japan, the only living species with which I am acquainted, the primary nerve appears as if split in two branches, which form the two margins of the leaves, and from which the secondary nerves ascend in forking. Another fossil species of *Salisburia* has been collected by Dr. J. Evans at Nanaimo, Vancouver's Island, in fragments too incomplete for a satisfactory comparison. None have been described from the Tertiary of Europe. There is one known from the Pliocene of Italy.

4. POPULUS MONODON, *Spec. nov.* Pl. xv, Fig. 1 and 2. P. foliis longis, latisque, lamina sexpolicari et ultra, deltoideo acuminatis, margine undulatis, vel parce irregulariter obtuse lobatis, nervo medio crasso, nervis lateralibus apertis, arcuatis.

Red shale.

This plant is represented only by the two specimens here figured; and as the base of the leaves is not preserved, the essential character, viz., the basilar nervation, cannot be taken into account. The large ovate or deltoid lanceolate acuminate leaves are probably rounded or cordate at the base, and have the borders either entire or undulate, or marked with a single obtuse lobe. The medial nerve is pretty thick, and the secondary ones are joined to it in an open angle and arched.

By its nervation and the size of the undulate scarcely lobed leaves, this species is closely related to *Populus Gaudini*, Heer, whose leaves are also entire or marked with a few round teeth. The European species differs only by its proportionably narrower and longer acuminate leaves.

5. POPULUS MUTABILIS, VAR. REPANDO-CRENATA, *Heer*. Pl. xviii, Fig. 4, 5, 6. P. foliis longe petiolatis, ovato ellipticis, lanceolatis, basi cuneato attenuatis, margine repando crenatis, nervo medio crasso, nervis lateralibus sub-curvatis.

Red shale.

Though the whole form of the leaves cannot be seen from the fragments found and figured, all the appreciable characters refer these fossil leaves to the species described by Prof. Heer, Flor. Tert. Helv., II, page 22, Pl. lxi, Fig. 12, 13, 14, and Pl. lxii, as one of the varieties of his *Populus mutabilis*. The broad medial nerve, the long petiole, the crenate-lobed borders of the leaves, and the disposition of the secondary nerves are alike. Both leaves represented in our Fig. 4 are obscure. The long petiole is flattened and the secondary veins are indistinct, or rather look as if they had been split by maceration. As much as can be seen from the fragments, the leaves were of large size, ovate-lanceolate,

wedge-form at the base or narrowed to the long thick petiole, and wavy crenate on the borders.

6. Salix Worthenii, *Spec. nov.* Pl. xv, Fig. 7. S. foliis in petiolum sensim attenuatis, exacte lanceolatis acutis, margine integerrimis, nervo medio angusto, nervis secundariis gracilibus, numerosis, sub angulo latiore exeuntibus, valde curvatis, alternatim brevioribus, camptodromis.

Soft white clay. La Grange, Tennessee; Mound City, Illinois.

The leaf here figured under the above name was communicated to me by Prof. A. H. Worthen, State Geologist of Illinois. A second, with the same shape and the same nervation, only smaller, was sent by Prof. James Safford, from La Grange, Tennessee.

The leaves of this willow are exactly lance-shaped, equally narrowed toward the point, and the petiole proportionably broad and short. The nervation is distinct, though the secondary nerves are thin. These come out of the medial nerve in an open angle and, from the middle, curve strongly upwards along the borders. Alternately shorter and longer, the shorter ones divide by veinlets, and anastomosing with branches of the long ones, they form a reticulation of pretty large square or polygonous areas.

I do not know of any living species which this one resembles. Its nearest relatives among fossil plants are, for the form of the leaves, *Salix integra*, Gopp., and for the nervation, *Salix tenera*, Al. Braun, both from Œningen. Indeed, it should be considered as identical with this last species, if, according to Prof. Heer's remarks, its leaves are sometimes taper-pointed and narrowed, not only toward the point but toward the base. Fig. 10, Pl. lxviii, of Heer's Flor. Tert. Helvet., approaches this form, but our leaves are proportionably shorter and still more exactly lanceolate.

7. Salix tabellaris, *Spec. nov.* Pl. xvii, Fig. 4. S. foliis elongatis, ultra pollicaribus latis, linearibus, margine parallelis, integerrimis, in petiolum attenuatis; nervo medio lato, nervis secundariis numerosis, irregularibus, angustis, camptodromis.

Soft white clay.

The leaf appears short petioled. From the width of the medial nerve, and from its gradual decrease up to the broken point, the blade of the leaf is at least twice as long as the preserved part of the specimen. The borders are exactly parallel and entire; the surface smooth, apparently shining. The secondary nerves are irregular, generally long ones, curving along the margins, alternating with short ones, or sometimes coming out of the medial nerve in various angles of divergence.

Except that the leaves are broader and the borders exactly parallel, our species would appear identical with *Salix longa*, Al. Braun, from Œningen. As *Salix angusta*, Al. Braun, also from Œningen, may be, according to Prof. Heer, a mere variety of *Salix longa*, though its leaves are narrower, our species might be as well considered as a variety with

broader leaves of the same species. The three forms here considered have as common characters the peculiar great length of the leaves, the entire margins, the broad medial nerve, and thick petiole.

8. QUERCUS MOORII, *Spec. nov.* Pl. xvi, Fig. 1, 2, 3. Q. foliis coriaceis, oblanceolatis, vel obovatis oblongis, elongatis, subobtusis, margine remote, breviter serratis; nervis secundariis, sub angulo latiore egredientibus, curvatis, craspedodromis.

Red shale.

The peculiar nervation of this beautiful species of oak shows the identity of the three specimens here figured. The secondary nerves, emerging from the medial one in an open angle (50 to 65°), curve upwards, and preserving about the same thickness in their whole length, abruptly bend backwards near the margin in entering the teeth. These secondary nerves are mainly opposite near the base, but become alternate and more distant in the upper part of the leaves. Judging from this appearance, and also from the scarcely decreased thickness of the medial nerve, the preserved part of the large leaf, Fig. 1, is not more than one-half of its whole length. Another specimen of the same species, which has not been figured, on account of obliteration of its borders, measures, from the top to near the base of the petiole, six inches, and is two and one-half inches broad. In the same proportion, the large leaf, which is four and one-half inches broad, would be nearly one foot long. These dimensions, compared with those of some oak leaves of our time, with the leaves of *Quercus macrocarpa*, Mich., for instance, are not extraordinary. This oak is related also to our fossil species by its nervation and the general outline of its oblanceolate leaves.

I do not know any other living species to which this fossil oak might be compared, except, perhaps, to *Quercus densiflora*, Hook, from California. It is named for Rev. W. D. Moore, a voluntary and most valuable coadjutor of Prof. Hilgard in his survey.

9. QUERCUS LYELLII, *Heer.* Pl. xvii, Figs. 1, 2, 3. Q. foliis subcoriaceis, lanceolatis, acutis vel brevi acuminatis, basi in petiolo brevi attenuatis, margine integris, undulatis, nervo medio recto, nervis secundariis apertis, curvatis, ramulo superiore margine approximato.

Red shale.

No difference is perceivable between the figures given by Prof. Heer of this species, in his Fossil Flora of Bovey Tracey, Pl. lxiii, Fig. 2 to 9, and ours. The general outline of the leaves, their margins entire or wavy, the direction and branching of the secondary nerves, the reticulation also, all is similar. In the three broken specimens here figured, the three essential forms indicated by the author of this species are even recognized: Narrow lanceolate leaves tapering toward the base, with slightly undulate borders as in Fig. 1; longer, proportionately narrower leaves, with nearly parallel sides, as in Fig. 3;

broader more distinctly undulate leaves, with a more abruptly narrowed base, as in Fig. 2. The primary nerve is of medium thickness; the angle of divergence of the secondary ones is about 50°. In our specimens the secondary nerves are generally opposite from the base of the leaves up to the middle, a character marked also in Heer's Fig. 6. They nearly reach to the borders, where they fork, the upper branches running along the borders and uniting to the next. The areas are divided into secondary ones by continuous, sometimes forking veinlets, forming a kind of irregularly polygonal reticulation, which still incloses a more delicate subquadrate one. Prof. Heer points out the relation of this fossil oak to some species now living in Mexico: *Quercus Xalapensis*, Thunb., *Q. undulata*, Web. This type has many representatives in the Miocene of Europe.

10. Quercus retracta, *Spec. nov.* Pl. xvi, Figs. 4, 5. Q. foliis coriaceis, politis, obovatis, oblongis, vel lineari lanceolatis, integerrimis; nervo premario plano, recto; secundariis tenuibus, horizontalibus vel retro curvatis, camptodromis imperfectis, arcis abreviatis.

Red shale.

I have figured the only fragments, though small, found of this species. By the form of the leaves, evidently very variable, and by its peculiar nervation, it has a marked relation to our living *Quercus aquatica*, Catesb., of the Southern States. With generally obovate or oblong lobed leaves, this oak has also narrow linear entire leaves, whose nervation is scarcely different from that of the fossil species as marked Fig. 4 a. *Quercus elœna*, Heer, of the Œningen stage of the Tertiary of Europe, is also closely related to the Mississippi species. It may be identical, but our specimens are too incomplete to allow a satisfactory comparison.

11. Quercus Chlorophylla, *Ung.* Pl. xvii, Figs. 5, 6, 7. Q. foliis coriaceis, ovatis, oblongis, obtusis, vel apice rotundatis, quando que sub-emarginatis, integerrimis, margine reflexis, nervis secundariis tenuibus, obsoletis, camptodromis, angulo acuto egredientibus.

Red shale.

As far as can be ascertained in comparing fossil leaves whose nervation is undiscernible, our species is identical with the one described under the above name by Prof. Unger, Chlor. Protog., page 111, Pl. xxxi, Fig. 1. However, it is not certain that these leaves belong to an oak. Oval, thick, entire coriaceous leaves of the same form as ours are found in different genera of living plants. The author compared this species to *Quercus imbricaria*, Mich., *Q. cinerea*, Mich., and *Q. virens*, Ait. But all these species of ours have a well-marked nervation, and their leaves are thinner or less coriaceous.

12. Celtis brevifolia, *Spec. nov.* Pl. xx, Figs. 4 and 5. C. foliis ovatis, acutis, vel acuminatis, brevibus, integerrimis, basi rotundatis, latere uno latiore inæqualibus, nervo medio recto, secundariis distantibus, oppositis, imperfecte acrodromis, nervulis subcontinuis, parallelis.

Red shale.

These leaves are likely acute or short acuminate. Their unequal round base resembles that of leaflets of a compound leaf. But I do not know of any having like form of leaves and such a peculiar nervation. *Celtis Mississippiensis*, Bosc., of our times, most resembles the fossil species. Its leaves are longer, indeed, and proportionally narrower; but especially at the base of the branches, leaves are casually short and broad. The base is unequal and rounded, and the secondary nervation and ultimate reticulation similar to that of our fossil leaves, marked Fig. 5 a.

13. FICUS SCHIMPERI, *Spec. nov.* Pl. xviii, Figs. 1, 2, 3. F. foliis membranaceis, ovato lanceolatis, acuminatis, basi rotundatis vel subtruncatis, integris, undulatis, tri subquinque nerviis, inæqualibus; nervis secundariis camptodromis, nervulis distantibus, continuis.

Red shale.

These fine leaves are the most numerous and best preserved of the specimens from Mississippi. Numerous as they are, nevertheless, no trace of a petiole is seen on any of them, though they were evidently stalked. Their general form is ovate acuminate, with round base, and entire, more or less undulate borders. The two inferior pairs of the secondary nerves are generally not far distant from each other; sometimes, as in the large leaf, Fig. 3, they become nearly connected, and the basilar trinervation becomes a five-compound nervation. This peculiarity, more marked still in other of these fossil leaves, seems to indicate the identity of both *Ficus truncata* and *Ficus Ruminiana*, Heer, to which our species is related. For the essential difference between them is the quinque-nervation of the first and the trinervation of the second. In our species the angle of divergence of the secondary nerves is more acute, the veins and veinlets more deeply marked, these being continuous and forming broader areas, subdivided into an ultimate minute irregularly quadrate reticulation, as in *a*, Fig. 1.

14. FICUS CINNAMOMOIDES, *Spec. nov.* Pl. xvii, Fig. 8. F. foliis late ovatis, basi rotundatis, integerrimis, irregulariter trinerviis; nervo medio arcuato, nervis secundariis crassis, angulo acuto sinu obtuso egredientibus, subtus ramosis.

Soft white clay.

If this leaf, represented by one broken specimen only, is, as it seems, pointed or acuminate, it has some likeness to *Ficus Tiliæfolia*, Heer, as it is figured, Flor. Tert. Helvet., Pl. lxxxiii, Fig. 3. Its nervation presents a kind of anomaly in this: that being unequally tricompound at the base, the secondary nerves branch in the same way as they do in this genus when the basilar nervation is in five. The secondary nerves unite to the arched medial one by a small obtuse sinus. The form of the leaf is about round, with perfectly entire borders.

15. Laurus pfdatus, *Spec. nov.* Pl. xix, Fig. 1. L. foliis coriaceis, oblanceolatis, in petiolum longe attenuatis integerrimis; nervo primario latiore, plano, nervis secundariis tenuibus, sub angulo acuto 30° egredientibus, camptodromis, areolatione ultima punctiformi.

Red shale.

This leaf is made up of two fragments. It is apparently short-stalked; its shape is oblanceolate, the entire borders gradually descending to the base and tapering upwards from the middle into a slightly obtuse point. The secondary veins are thin but distinct, nearly as slender as the veinlets, and somewhat flexuous or variously bending to branching points. Among fossil plants, this species is distantly related to *Laurus princeps*, Heer, a species abundant in the Miocene of Europe. The long tapering base of the American fossil is its essential specific character.

16. Cinnamomum Mississippiense, *Lesqx.** Pl. xix, Fig. 2. C. foliis subcoriaceis, ovatis, lanceolatis, acuminatis, basi in petiolo brevi, semipollicari longo, subdecurrentibus, integerrimis, triplinerviis, nervis lateralibus ultra $\frac{2}{3}$ evanidis.

Brown coarse sandstone.

This species is, like the former, represented by some specimens, which, though separately incomplete, show, taken altogether, the entire form, except the point. It pretty closely resembles *Cinnamomum Buchi*, Heer, Flor. Helvet. Tert. ii, page 90, Pl. xcv, Fig. 1 to 8, whose leaves are variable. Our leaf evidently differs in its more exactly ovate form, being largest below the tapering point, which is accordingly longer than the more abruptly rounded base. In *Cinnamomum Buchi*, on the contrary, the greatest enlargement is above the middle; therefore its leaves are more abruptly narrowed into a point, while they are more gradually narrowed toward the petiole. The reversed figure of *C. Buchi* would be just like that of *C. Mississippiense* in its natural position. From *Cinnamomum Heerii*, Lesqx., Amer. Journ. of Sci. and Arts, § 2, vol. xxvii, p. 361, to which this species is also allied, it differs by the leaf being twice as large, and by the relatively narrower nerves. The junction of the lateral with the medial nerve is not as high up above the base as in the species of Vancouver's Island. It is the only fossil leaf of a *Cinnamomum* obtained from the Atlantic slope.

17. Banksia Helvetica, *Heer.* Pl. xvi, Fig. 6. B. foliis coriaceis, sessilibus, oblanceolatis, obtusis, integerrimis, basi sensim attenuatis, truncatis; nervo medio valido percurrente, nervatione hyphodroma.

Red shale.

The leaf is about two inches long, half an inch in its broadest part, round obtuse above,

* Dana's Manual of Geology, page 513, Fig. 94.

with its lower part slightly decreasing towards the base and abruptly rounded or truncate on both sides of the basilar part of the nerve. By its peculiar form, its percurrent slightly curved medial nerve, and its obscure reticulation, this leaf is referable to Heer's species in Flor. Helv. Tert. ii, page 98, Pl. xcvii, Figs. 44 to 48. It is essentially similar to both specimens of Fig. 44, which show a truncate base, a curved medial nerve, and an obtuse point like ours. In the American leaf the *areolæ* appear smaller and more distant than are figured in European specimens.

18. PERSEA LANCIFOLIA, *Spec. nov.* Pl. xix, Figs. 3 and 4. P. foliis lanceolatis, utrinque attenuatis, acutis, vel acuminatis, integerrimis, nervo medio crasso, nervis secundariis angulo acuto egredientibus, distantibus, curvatis, camptodromis.

Red shale and yellow coarse clay.

A number of specimens have been collected, both on the red shales and the coarse clay, in the same state of preservation as those which I have figured. The form of the point and of the basilar part of these leaves is not known. The details of nervation are obsolete, the medial nerve is remarkably broad, the secondary ones curve upwards from an angle of divergence of about 40°. The lanceolate entire, apparently membranaceous leaves, enlarged in the middle, taper equally to both ends. I do not know of any near relation to this species. It may be compared to *Persea speciosa*, Heer, from the Upper Miocene of Europe.

19. CEANOTHUS MEIGSII, *Spec. nov.* Pl. xix, Figs. 5, 6, 7. C. foliis petiolatis, late ovatis, basi truncatis, cordatisve, in longum apicem attenuatis, obtuse æqualiter serratis, triplinerviis, nervis secundariis infimis basilaribus, tenuibus, superioribus crassis, nervo primario subæqualibus, arcuatis, extrorsum inferne ramosis, acrodromis imperfectis.

Yellow coarse clay, Mississippi; soft white clay, La Grange, Tennessee.

Allied to *Ceanothus Tiliæfolius*, Ung., of the Miocene of Europe, this species also resembles our living *Ceanothus Americanus*, L. The difference is essentially in the long narrow point of the fossil leaves, in their large size, and in the obtuse and more equal teeth which surround them. Both species have in common the general form of the leaves and the nervation. This genus, still represented by many species in our flora, especially in California, has apparently left numerous representatives in the recent formations of our country. There is in Prof. Hilgard's collection a number of specimens of this species, and from eight specimens sent from La Grange, two of them belong to it. I have found also in the chalk-banks of Columbus, Kentucky, another species still more like *Ceanothus Americanus*, L., indeed undistinguishable from it,* with shorter, obtusely pointed, more irregularly serrate leaves.

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* Journal of Science, § ii, vol. xxvii, p. 365.

The specimen copied, Fig. 7, was collected near La Grange, by Prof. B. Meigs, and communicated by Prof. James Safford, to whom I am indebted for all the specimens from Tennessee.

20. SAPINDUS UNDULATUS, *Al. Braun.* Pl. xxii, Fig. 6. S. foliis membranaceis, lanceolatis, subobtusis, basi attenuatis, inæquilateralibus, subfalcatis, margine undulatis; nervo medio crasso, nervis secundariis sub angulo acuto egredientibus, vix curvatis.

Red shale.

Our leaf is shorter than the figure given of this species by Heer, Flor. Tert. Helv., Pl. cxxi, Fig. 5, but there is no other difference. It is slightly obtuse, inequilateral, falcate; the nearly opposite secondary nearly straight nerves diverge in acute angles from the thick primary one; all characters found alike in both the European and the American leaves.

21. RHAMNUS MARGINATUS, *Lesqx.* Pl. xxii, Figs. 3, 4, 5. Geol. Report of Arkansas, II, page 319, Pl. vi, Fig. 1. R. foliis subcoriaceis, petiolatis, oblongis, ovalibus, acutis vel subobtusis; margine (reflexo?) integris, nervo medio crasso, nervis secundariis angulo acuto egredientibus, secundum marginem decurrentibus, valde curvatis nervulis parallelis.

Red shale.

This marked species is closely related to, if not identical with *Rhamnus Carolinianus,* Walt. The leaves of the fossil plant are broader, more abruptly narrowed to the petiole, and more obtuse at the point; the medial nerve is slightly broader and the petiole is longer. The secondary nerves curve along the borders, closely following them, thus appearing to form a margin all around the leaves. In specimens of *R. Carolinianus,* collected in the mountains of Arkansas, and whose leaves are somewhat thick and shining, the secondary nerves run to and along the reflexed margin in such a way that maceration and compression would, I think, produce the same apparent border as is seen on the fossil leaves. In large leaves also of the Arkansas variety, the medial nerve is as broad, and the petioles are as long as in the fossil species. The best preserved specimens of the collection are here represented. The leaves are very variable in size, and apparently more or less pointed. This species is not intimately related to any fossil one of the tertiary of Europe, where the genus is nevertheless abundantly represented.

22. JUGLANS APPRESSA, *Spec. nov.* Pl. xx, Fig. 6. J. foliis lineari lanceolatis, margine dentibus appressis obscure serratis, nervo medio valido, nervis secundariis ex angulo subrecto valde curvatis, camptodromis, crassioribus.

Red shale.

The reticulation of this fragment of leaf shows it to belong to a *Carya* or a *Juglans.* By comparison with leaves of *Juglans rupestris,* Engl., a species from California, the

nervation, reticulation, and also the obsolete serration, appear much alike. In the Miocene Flora, *Juglans Heerii*, Ett., is its nearest relative. The nervation and reticulation, as figured in Heer's Flor. Tert. Helvet., Pl. xcix, Fig. 236, are similar.

23. JUGLANS SAFFORDIANA, *Spec. nov.* Pl. xx, Fig. 7. J. foliis ovato lanceolatis, acutis, basi inæqualiter cordatis, remote obtuse serratis, nervis secundariis angulo subrecto egredientibus, arcuatis.

White soft clay, La Grange, Tennessee.

Differs from the former by the short, unequally cordate, lanceolate pointed leaves, and by the more prominent, obtuse, and distant teeth. The secondary nerves are of about the same thickness and have the same direction, being in an open angle on the medial nerve, and somewhat abruptly curving upwards from above the middle. Near the borders they appear to fork, one branch entering the serrature, the other curving upwards to the sinus and anastomosing. The details of nervation are rendered obscure by a coat of varnish on the specimen; they are delineated, as far as they can be traced, in *a*, Fig. 7.

24. MAGNOLIA HILGARDIANA, *Lesqx.* Pl. xx, Fig. 1. Geol. Report of Arkansas, II, page 319, Pl. vi, Fig. 1. M. foliis membranaceis, oblongis, ovalibus, integris, undulatis; nervo medio angusto, nervis secundariis approximatis, camptodromis.

Red shale.

This fine leaf, of an elongated oval form, is apparently pointed or acuminate, about one foot long, with undulate borders, rounded or abruptly narrowed toward the petiole. The secondary nerves are pretty near each other; their angle of divergence, about 60°, is the same in all our fossil Magnolia of this formation. I do not know of any fossil or living species related to this.

25. MAGNOLIA LAURIFOLIA, *Spec. nov.* Pl. xx, Figs. 2 and 3. M. foliis oblanceolatis, acutis vel acuminatis, in petiolum sensim attenuatis, integerrimis; nervo medio recto, angusto, nervis secundariis numerosis, camptodromis, nervulis tenuissimis, areolis ultimis irregulariter polygonis.

Red shale.

The nervation of this species is about of the same kind as that of the former, the secondary nerves being slightly narrower and more generally opposite. But the shape of the oblanceolate, tapering downward, and quite entire leaves is far different. This form of the leaves distantly allies this species to *Terminalia Radobojensis*, Ung. No living species of ours is comparable to it.

26. MAGNOLIA LESLEYANA, *Spec. nov.* Pl. xxi, Figs. 1 and 2. M. foliis obovatis, breviter obtuse acuminatis, in petiolum longe attenuatis; nervo medio valido, transversim eroso striato; nervis secundariis distantibus, irregularibus, secundum marginem valde curvatis.

Red shale.

The long obovate leaf, narrowed into an obtuse point, and gradually decreasing toward the petiole; the broad medial and the irregular secondary nerves are the essential characters of this species. The form of the leaves resembles that of *Magnolia laurifolia;* but the nervation is different. By the irregularity and the distance of the secondary nerves, and by the shape of the leaves also, our fossil species is related to the living *Magnolia umbrella*, Lam.; though distinct enough by the more acute angle of divergence of the secondary nerves, and by the obtuse point.

27. MAGNOLIA OVALIS, *Spec. nov.* Pl. xxi, Figs. 3 and 4. M. foliis brevi petiolatis, late ovalibus, obtusis, basi rotundatis, abrupte, brevissime in petiolum decurrentibus, nervo primario lævi, nervis secundariis camptodromis, distantibus.

Red shale.

In this species the leaves are thin, broad oval, and broadly obtuse, both at the top and at the base, which abruptly descends to the short petiole. The secondary nerves are still more distant than in the former, and not quite so much curved upwards. It is altogether a species of a peculiar type, which does not appear to have any representative in our present flora,* and is not comparable to any known fossil plant.

28. MAGNOLIA CORDIFOLIA, *Spec. nov.* Pl. xxii, Figs. 1 and 2. M. foliis submembranaceis, tenuibus, late ovatis vel rotundatis, brevi acuminatis, basi cordato-truncatis, in petiolo crasso abrupte subdecurrentibus, nervo medio lato, nervis secundariis arcuatis.

Red shale.

The similarity of this species to our *Magnolia cordata*, Michx., of the Southern States, is striking. But for the thickness of the medial nerve and of the petiole, an appearance which might be explained by compression in the process of petrification, and for the broader angle of divergence of the secondary, slightly arcuate nerves, the identity of both species could not be denied. The basilar form of the leaves and their general outline are the same, for it is evident, from the direction of the margins near the broken point, that these fossil leaves are also acuminate. These are larger than generally in the living species; but all our Magnolias bear proportionally large leaves, according to climatic circumstances. The substance of the leaves appears as thin as in the former species.

29. ASIMINA LEIOCARPA, *Spec. nov.* Pl. xv, Fig. 8. A. seminibus oblongo ovalibus, uno apice truncatis, altero acutis, lævibus, pollicem longis, vix semi-latis.

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* Prof. Gray informs me that species of Magnolia with obtuse leaves inhabit Japan; but none of them with such nearly round and large leaves as our fossil plant.

Red shale.

There is not any difference of form between this seed and those of our common Pappaw (*Asimina triloba*, Dun.). But it would be over-presuming indeed, to try to identify species from a mere flattened seed, half imbedded in the stone. In the same fruit, the seeds of the Pappaw vary greatly in form and size; they are nevertheless generally undulated or wrinkled across, a character which is not seen in the fossil.

30. PHYLLITES TRUNCATUS, *Spec. nov.* Pl. xvii, Fig. 9. P. foliis oblongis, lanceolatis, integris, undulatis, basi in petiolo brevi truncato decurrentibus; nervis secundariis gracilimis, distantibus, camptodromis.

Red shale.

The leaf is oblong, with undulate entire borders, apparently lanceolate pointed, narrowed to the petiole or to the base of the medial nerve, where it is slightly decurrent and abruptly cut, forming a short winged-like petiole. The secondary nerves are indistinct and very slender. Prof. Charles Gaudin, in his 4th Memoir of *Contributions a la flore fossile Italienne*, has published, page 23, Pl. v, Figs. 6 and 7, two leaves of the Post tertiary, which he considers as *Viburnum tinus*, S., now living in the South of France. By their form and nervation these leaves appear exactly similar to ours.

Is it possible now, from the small number of fossil plants described above, to draw any conclusion concerning their geological distribution? And first, do the plants by their analogy indicate synchronism between the various strata where they have been found?

As it is remarked in the introduction, our leaves are imbedded, either in a red, laminated, ferruginous shale, of a fine-grained compound, in whose layers the impressions of leaves are horizontally marked and distinct, though their substance is totally destroyed; or on a soft white clay, easily cut with the knife, where the impressions are equally distinct and horizontal, and the substance of the leaves also destroyed; or on a yellowish coarse sandy clay, casually veined with a soft white clay like the former. In this matter, the leaves are well defined, their substance is more or less preserved; but they are mostly distorted or folded, as if they had been transported with the materials in which they are imbedded. One of our species only is on a coarse brownish sandstone, whose compound is unlike any of the former; the substance of the leaf is fully preserved.

According to Prof. Hilgard's statements, as much as can be seen from the disposition of the plants-bearing strata, there is not any great difference in their horizontal stations. He acknowledges the lithological characters as being heterogeneous, but he accounts for this by the interposition of materials of various kinds, especially of ferruginous sand, modifying the nature of underlying clays, and by the various modes of transportation and deposition of these materials. "As for the red shales," he says, in a letter on the subject,

"I doubt very much whether they can be considered as representing by themselves a definite stage, for they occur wherever the white clays are immediately overlaid by the highly ferruginous strata of the Orange Sand." Prof. James Safford, who has studied the same group in Tennessee, writes: "That the lithological differences do not indicate any distinct formation; and that the red shales are simply local beds or layers generally of very limited extent." The question of synchronism is perhaps satisfactorily settled by these remarks. Nevertheless, as the plants have not been found at the same locality, in strata of various lithological compounds, they might, by their specific differences, indicate peculiar stages of a same geological series. Prof. Hilgard appears to have this view. For, in his general section of the Tertiary of Mississippi,* under the general division of Lignitic of Northern Mississippi, or Northern Lignitic group, underlying the Claiborne group, he places the leaves-bearing strata in the following order:

a. Gray clay and sands of Tippah, sometimes transformed into red shale. (Contains all our species of leaves marked red shale.)

b. Gray clay of Lafayette and Calhoun, with *Sabal*, &c. (Contains the species marked white soft clay.)

c. Gray clay of Winston, with *Calamopsis*. (Contains the species marked yellow coarse clay.)

The leaves on brown sandstone, *Cinnamomum*, are placed by the author with the division *b*, a connection which does not seem in accordance with what is shown by his diagram, page 116.

In considering the plants by themselves, and studying their relation of forms, we find in the red shale, twenty-two species described here from the Mississippi, and ten species formerly described,† from Somerville, Tennessee; in all thirty-two species. From the white soft clay of both States we have six species only. None of these are either identical or even analogous with those of the red shale. Indeed, taken altogether, the flora of each deposit has a peculiar facies. The first contains Oaks, Poplars, Magnolias, mostly forest species, while the other has the Willows and the Palms, rather swamp plants. Between the species of the white clay and those of the coarse yellow clay, though the number is very limited, there is on the contrary as great an analogy as between the lithological compounds of the strata. They have in common *Ceanothus Meigsii*, abundant in the white clay of Tennessee as in the yellow clay of Mississippi. One has a Palm, *Calamopsis*, the other has one also, a *Sabal*, both apparently belonging to those dwarf Palm trees which generally inhabit deep swamps. In the yellow coarse clay we find a link of connection with the flora of the red shales in *Persea lancifolia*, which is common to both.

Though the differences even in the general facies of these fossil plants may be well

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* Report on the Geology and Agriculture of the State of Mississippi, page 108.

† American Journal of Science, § 2, vol. xxvii, page 363.

marked, they cannot be taken, I think, as conclusive indication of a difference in the horizontal position of the strata. At least not yet, when the materials for comparison are so scanty. Changes in the vegetation are often merely local, and caused by casual circumstances. For example, swamps along water-courses, have preserved in their clay deposits, water or shore plants, either fallen from trees grown in the same place, or transported by currents; while swamps in the forest, though contemporaneous, have in their clay deposits true forest leaves of a different character from those of the former. Moreover, the floras of the recent formations, principally of the Tertiary, have been far more local or grouped than they were in the old formations, especially during the coal epoch, whose vegetation is of the widest general uniformity. Even our red shale, though the plants which it contains have the same general facies, indicate specific differences of the same kind. For, in the specimens of Sommerville, Tennessee, and those of Tippah, Mississippi, there is only one species, *Quercus Lyellii*, common to both. It is the leaf, which from a broken specimen, and from its likeness with our now living *Laurus Caroliniensis*, I have previously considered as identical with it.*

A second question, more important still, concerns the age of the formation where our fossil leaves have been found, as indicated by the species here described. It must be admitted, at first, that the attempt to draw some positive deductions on this subject, with the small amount of materials at present collected, and without any point of comparison from our American formations, may result in unreliable conclusions. For we know nothing yet of the fossil flora of our mesozoic time; even the line of separation between the vegetation of the Tertiary and that of the Cretaceous is not traced. And if we look for comparison to what is known of the fossil plants of Europe, we find there with short memorials of Eocenic and Cretaceous floras, a splendid record of Miocenic vegetation,† where most of the types of our actual flora are represented together with species analogous to some which are recognized as belonging to the American Cretaceous. It is not surprising that a comparison made with such materials is liable to error. Yet, this is not a reason why we should lay aside our fossil plants with distrust. On the contrary, it is important to examine them carefully now and to begin by recording facts and data for future use. For, as the geological position of the group where they have been collected is well ascertained, these botanical remains, once collected in number and well studied, may furnish a point of comparison for future discoveries.

The horizon of this group, which we call, with Prof. Hilgard, *North Lignitic*, is marked first by a section by this eminent geologist, of what he considers the tertiary strata of Mississippi.

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* American Journal of Science, § 2, vol. xxvii, page 363.

† Especially in the admirable works of Heer.

Beginning at its top, it has:*

No. 10. The Grand Gulf stage, with lignitic beds, tree palms, exogenous trees, . . . 80 feet.
" 9. The Vicksburg stage, with crystalline limestone and fossil shells, ... 80 "
" 8. The ferruginous rock of Red Bluff, with fossil shells, ... 12 "
" 7. The Lignitic clay and Lignite of Vicksburg and N. Brandon, ... 20 "
" 6. The Jackson stage, with blue marls and fossils, ... 80 "
" 5. The Lignitic clay and Lignite of Jackson.
" 4. The Claiborne stage in three divisions, A. calcareous with fossils.
" 3. Lignitic clay of Clark County.
" 2. B. Silicious Claiborne, sandstone, &c., with fossils.
" 1. Northern Lignitic, where our fossil plants have been found, and whose divisions are indicated above. Thickness, ... 425 feet.

This section is most satisfactorily completed by another given by Prof. J. Safford, in a very interesting paper on the Cretaceous and Superior Formations of West Tennessee.† This section, abridged like the former, indicates from the lower strata upwards.

1st. The Coffee Sand, the inferior group of the Cretaceous in Tennessee. Under gravel and ferruginous conglomerate, it has, at its base, slaty clay and yellow sand, with fragments of fossil wood and leaves, ... 200 feet.

2d. The Green Sand group or shell bed. The author enumerates 34 species of shells from this group, which contains also, though more rarely, leaves and wood, ... 200 to 350 feet.

3d. The Ripley group, mostly made up of stratified sands. Twenty species are named from local fossiliferous beds in the upper part of the series, ... 400 to 500 feet.

4th. The Porter's group, formerly included in the following, from which it is distinct only by its proportionally more laminated or slaty beds of clay, ... 2 to 300 feet.

5th. The La Grange group, rightly considered by the author as the equivalent of Hilgard's Northern Lignitic, for it contains the same species of fossil plants in strata of exactly the same compound. This group occupies a belt 40 miles wide, along the State line of Tennessee and Mississippi, between the Tennessee and the Mississippi River. Its thickness is about . . . . . 600 feet.

6th. The Bluff lignite, apparently the equivalent of the chalk-banks of Columbus, Kentucky, which I have considered, with Dr. D. Owen, as Pliocene.

7th. The Bluff gravel, which, in Tennessee as well as at Columbus, Ky., overlies the above group. It is a ferruginous chert or coarse orange sand, mixed with shells, mostly identical with species of our time, and where also have been found the bones of *Megalonix Jeffersonii*.

8th. The Bluff loam, a soft buff-colored clay, whose animal remains are all, but one, represented by species living in the water of the Mississippi Valley.

The localities where our fossil plants have been collected, Tippah, Mississippi, La Grange and Sommerville, Tennessee, are about in the middle of the belt occupied by the

* This section is abridged. The author names the essential species of fossil shells found in connection with each division.

† American Journal of Science, § 2, vol. xxxvii, page 360.

Northern Lignitic group. As this group is underlaid by Cretaceous strata, and overlaid in Tennessee by a Pliocene formation, it seems that it should be considered as the representative of the Tertiary of that country; and if so, the plants in its middle should be of the Miocene. But in Mississippi, the Northern Lignitic appears overlaid, at least as far as stratigraphical evidence can show it, by the Vicksburg, Jackson, and Claiborne stages, which are generally referred by geologists to the Eocene series. This would place it with the Eocene or the Upper Cretaceous.

How does this conclusion agree with the indications furnished by our described fossil plants? Two at least of these leaves, one *Phyllites* and one *Rhamnus*, are referable to species now living; four more are nearly related to living species also, and none of them represent any typical or peculiar form unknown in our actual flora, any genus effaced from it; but on the contrary, the whole group has the general facies of a group of plants of our time. This is certainly not the character of an Eocenic vegetation, which, according to the too general definition of Lyell, should not contain any living species.

In Europe the Eocene deposits which have been more thoroughly studied, and have furnished to science the largest collections of fossil plants, are those of Mt. Bolca, near Verona, Italy. With a large quantity of marine and fresh-water Algæ, they have especially species of the Genera *Drepanocarpus*, *Cæsalpinia*, *Eucalyptus*, *Eugenia*, *Guajacites*, *Xanthoxylon*, *Santalum*, *Aralia*, &c., which not only have not a single representative in the Northern Lignitic, but which present a far different type of vegetation. For, as it has been remarked by Prof. Heer, the flora of Mt. Bolca, like the other Eocenic floras of Europe, bears evidence of a tropical climate. The American types are very few in it, while the East Indian and the Australian have the predominance. Nothing of this kind is shown by our fossil plants of Mississippi. They are no more tropical than the present vegetation of the Southern States, and with scarcely any exception, all the types are American. On this point of view, as from their relation to forms of living plants, the leaves of the Northern Lignitic group appear most intimately related to the Miocene of Europe. To put this assertion in full evidence, let us pursue our comparison a little further.

Heer, in his *Flora Tertiaria Helvetica*, III, page 204, fixes the divisions of the Miocene of Central Europe as follows:

V.	Upper lignitic formation,	Œningen stage,	Upper Miocene.
IV.	Marine subalpine molasse,	Helvetic stage,	Middle Miocene.
III.	2. Marine formation of Basle,	Maintz stage,	Middle Miocene.
	1. Gray fresh-water, molasse,	Maintz stage,	Middle Miocene.
II.	2. Marine molasse of Ralligen,	Aquitan stage,	Lower Miocene.
	1. Lower lignitic formation,	Aquitan stage,	Lower Miocene.
I.	Marine molasse of Basle,	Tongrian stage,	Lower Miocene.

I have endeavored, as far as it was possible, to point out the relation of each of the plants of Mississippi, with species from a known geological stage. Putting the comparison in a tabular form, we have:

Species Described.	*Nearly related to or identical with*	*Geological Stage.*
1. Calamopsis Danai, *Lx.*	Calamopsis Bredana, *H.*	Œningen stage.
2. Sabal Grayana, *Lx.*	Sabal major, *Un.*	Aquitan "
3. Salisburia binervata, *Lx.*	Salisburia.	Pliocene, Europe; Cretaceous? California.
4. Populus monodon, *Lx.*	Populus Gaudini, *Fis.*	Helvetic stage.
5. P. mutabilis, *H.*	P. mutabilis, *H.*	Œningen "
6. Salix Worthenii, *Lx.*	Salix tenera, *Br.*	" "
7. S. tabellaris, *Lx.*	S. longa, *Br.*	" "
8. Quercus Moorii, *Lx.*	Q. densiflora, *En.*	Living.
9. Q. Lyellii, *H.*	Q. Lyellii, *H.*	Aquitan, (Bovey Tracey.)
10. Q. retracta, *Lx.*	Q. Elœna, *Ung.*	" stage.
12. Celtis brevifolia, *Lx.*	Celtis Mississippiensis, *Bos.*	Living.
13. Ficus Schimperi, *Lx.*	Ficus truncata, *H.*	Œningen "
14. F. cinnamomoides, *Lx.*	F. tiliæfolia, *Br.*	Maintz "
15. Laurus pedatus, *Lx.*	Laurus princeps, *H.*	Œningen "
16. Cinnamomum Mississippiense, *Lx.*	Cinn. Buchi, *H.*	Aquitan "
17. Banksia Helvetica, *H.*	Banksia Helvetica, *H.*	Œningen "
18. Persea lancifolia, *Lx.*	Persea speciosa, *H.*	" "
19. Ceanothus Meigsii, *Lx.*	Ceanothus tiliæfolius, *Ung.*	Aquitan "
20. Sapindus undulatus, *H.*	Sapindus undulatus, *H.*	Œningen "
21. Rhamnus marginatus, *Lx.*	Rhamnus Carolinianus, *Mx.*	Living.
22. Juglans appressa, *Lx.*	Juglans Heerii, *Ett.*	Aquitan "
23. J. Saffordiana, *Lx.*	"	" "
24. Magnolia Hilgardiana, *Lx.*	?	?
25. Magnolia laurifolia, *Lx.*	Terminalia Radobojensis, *Ung.*	Aquitan "
26. M. Lesleyana, *Lx.*	Magnolia umbrella, *Mx.*	Living.
27. M. ovalis, *Lx.*	?	?
28. M. cordifolia, *Lx.*	M. cordata, *Mx.*	Living.
29. Asimina leiocarpa, *Lx.*	A. triloba, *Dun.*	"
30. Phyllites truncatus, *Lx.*	Viburnum tinus, *L.*	"

From this table, on thirty species, without counting the fruit of Pappau, six are analogous or identical with living plants; nine with the Upper Miocene of Central Europe; two with the Middle Miocene, and eight with the Lower. Moreover, four of our plants are identical with Miocenic species of Europe. I do not think that it would be possible to find between two groups of plants, of far-distant countries, a more intimate relation than what is shown by this enumeration.

But we have, in the fossil leaves of Mississippi, a number of Magnolias, and the Euro-

pean Tertiary has none; while, per contra, the Upper Cretaceous of Europe, and also of America, have remains of this genus. Cannot then our plants belong to the Upper Cretaceous also? Do not they show any relation to those plants discovered in Nebraska by Meek and Hayden, and whose general character is so much like that of Tertiary plants, that from the descriptions given of them, they were considered by Prof. Heer and by myself as Miocenic species? Indeed, after examining the fossil plants of Nebraska, from the descriptions and figures of Capellini and Heer,* I can but admit that they have in their general facies something resembling the character of our Northern Lignitic leaves. Seventeen species are published by these authors: two *Populus*, one *Salix*, one *Betulites*, one *Ficus*, one *Platanus?*, three *Proteoides*, one *Aristolochites*, one *Andromeda*, one *Diospiros*, one *Cissites*, two *Magnolias*, one *Liriodendron*, and one *Phyllites*, of uncertain affinity. Six of these genera are represented in the Tertiary; hence the Miocenic facies of this small group of plants. This is nevertheless evidently a family or generic likeness, very uncertain indeed; for it is not marked by any close relation or identity of forms indicating contemporaneous existence. Magnolias appear in the deposits of Nebraska as in those of Mississippi; but they are not alike, not even of the same type, and those of the Northern Lignitic have, with species of our time, an affinity which is not marked in the others. Of the species of *Salix* and *Populus*, even the generic characters are not certain; *Aristolochites* and *Cissites* present a type of leaves totally at variance with any of the Miocenic flora and of our Mississippi species, while the three species of *Proteoides* indicate a predominance of Australian types, of which we find no trace in our leaves. Still I do not consider the question as solved. It can be only satisfactorily settled by recognized difference or identity of species collected in these strata of our American formations. For it may be that as we have in our Upper Cretaceous measures, dicotyledonous plants of genera which are still represented in our actual flora, like some of the Miocene of Europe, we may have Eocenic deposits with species still more related to some of our present vegetation; thus bearing a character approaching that of the same European Miocene. Under the uniform development of the geological measures of the Mississippi Valley, the typical forms may have escaped changes from disturbing influences, similar to those which have evidently modified, by repeated cataclysms, the recent formations of Central Europe.

The examination of our Northern Lignitic leaves raises questions of remarkable interest, especially on the distribution of vegetable species, on their modifications under certain influences, on the relation of groups of plants or general floras at divers geological times, either on our continent or in comparison with other countries; on the causes of the differences, changes, &c. &c., all problems which it should be too hazardous to try to study

* Phyllites Cretacés du Nebraska par MM. les Prof. J. Capellini et O. Heer (1866).

now. The mere mention of them is sufficient to show the importance of the researches among the remains of our old floras. This fact only seems to derive from the character of the leaves of the Northern Lignitic: that our present flora has types which are peculiar to it, and which are preserved in it since formations as old as the Cretaceous, where they were already recognizable.

APPENDIX.

ON FOSSIL LEAVES FROM FORT ELLSWORTH, NEBRASKA.

The previous paper was written, when, through the kindness of Dr. John Le Conte, I received a number of fossil plants collected near Fort Ellsworth, from the same strata where the leaves described by Messrs. Capellini and Heer had been obtained. Stratigraphy and animal palæontology have identified these formations as Upper Cretaceous. This communication is very opportune, for it enables me to bring into view for comparison the two groups of fossil plants whose character has just been discussed. And as a few of these plants are new, and others complete, by better specimens, some of the species published by Prof. Heer, this short Appendix is an interesting contribution to our American fossil botany. All the specimens are on brown coarse sandstone.

1. Populites microphyllus, *Spec. nov.* Pl. xxiii, Figs. 2 and 3.

Of this species the collection has only the two broken specimens figured here. The leaf is apparently nearly round or large oval, abruptly narrowed at the base, crenate serrate on the borders, with sharp teeth pointing outward; five-nerved at base like a *Populus*, with all the nerves and veinlets so deeply marked that the surface of the leaves is wrinkled. If the basilar five nervation and the peculiar denticulation of the borders seem to refer these leaves to *Populus*, their thick coriaceous texture and their wrinkled surface cannot be compared to any known species of that genus.

2. Phyllites betulæfolius, *Spec. nov.* Pl. xxiii, Fig. 4.

From the preserved part of this leaf, it appears nearly round, entire from the middle downward, coarsely serrate upwards, with large, somewhat obtuse teeth, and obtuse sinuses; the medial nerve is deep and narrow; the secondary alternate nerves of the same thickness, are at first horizontal, curving upwards near the border only, in going up to the

point of the teeth. Hence the nervation appears acrodrome. The texture of the leaves is apparently also coriaceous.

3. PERSEA NEBRASCENSIS, *Spec. nov.* Pl. xxiii, Figs. 9 and 10. P. foliis coriaceis, integerrimis, lineari lanceolatis, in petiolum longum attenuatis, nervo medio crasso, nervis secundariis suboppositis, angulo acuto egredientibus, obscuris, gracilibus.

The broad medial nerve, the long thick petiole, the narrow lanceolate coriaceous leaves, give to this species a marked appearance, which I cannot compare to that of any other fossil leaf. It is distantly related to *Persea lancifolia* of the N. Lignitic, and also to species of *Eugenia* of the Eocene of Mt. Bolca.

4. SASSAFRAS LE CONTEANUM, *Spec. nov.* Pl. xxxiii, Fig. 1. Quercus Benzoin? *Lesqx.*, Amer. Journ. of Science, § 2, vol. xxvii, page 360. S. foliis elongatis, ovato lanceolatis (acutis?), margine integris, undulatis; nervo medio valido, recto, nervis secundariis irregularibus, plus minusve flexuosis, sub angulo acuto egredientibus, inferioribus distantibus, secundum marginem longe curvatis.

The base of the leaf is apparently narrowed to the petiole; its form is lengthy oval, lanceolate, pointed perhaps obtusely; the inferior pair of secondary nerves is distant from the upper pair, separated from it by shorter irregular flexuous ones. This species is closely related to, if not identical with, *Quercus Benzoin*, Lesqx., of Nanaimo, Vancouver's Island. The form of the leaves is similar, the nervation is of the same type, but in the Nanaimo species the secondary nerves appear thicker, and the lower ones are exactly opposite. This last character is of no moment, I think, for in our own *Sassafras officinale* the lower secondary nerves, like the upper ones also, are as often alternate as opposite. Until better specimens prove identity or specific difference between the Nebraska and the Nanaimo species, I shall consider this last as a mere variety of *Sassafras Le Conteanum*.

5. CINNAMOMUM HEERII, *Lesqx.* Pl. xxxiii, Fig. 12. Amer. Journ. of Science, § 2, vol. xxvii, page 361. C. foliis ovatis, acutis vel brevi acuminatis, integris, triplinervis, nervis lateralibus margine non parallelis, usque ad $\frac{3}{4}$ ascendentibus, extus ramosis.

The incomplete diagnosis formerly given of this species, loc. cit., was from a specimen of which the lower part only is preserved. It has a short petiole, and the lateral nerves unite above the base of the leaf. In the specimen here described the lower part has been destroyed by grinding the stone to give it the form of a leaf. In both the nervation is similar. The substance of the leaves is somewhat coriaceous and the nervation well marked, though not so thick and deep as in *Cinnamomum Mississippiense*.

6. PROTEOIDES ACUTA, *Heer.* Pl. xxiii, Figs. 5, 6, 7.

These fragments show the form of the whole leaf except the extreme point, which is figured by Heer, Phyll., page 17, Pl. iv, Figs. 7 and 8. The borders are undulate; the

length of the leaves at least half one foot, their texture pretty thick, without any trace of secondary nerves.

7. PROTEOIDES GREVILLIÆFORMIS, *Heer*. Pl. xxiii, Fig. 8.

The specimen shows nearly the entire leaf; its point may be somewhat obtuse or long acuminate; its form is scythe-shaped, enlarged above the base and narrowed to a short petiole. The medial nerve is well marked; the secondary ones very thin, emerging in a very acute angle, few, distant, and ascending along the borders.

8. ANDROMEDA PARLATORII, *Heer*. Pl. xxiii, Fig. 11.

This specimen, like the former, completes one of Heer's species, of which only the middle part was known (Phyll., page 18, Pl. i, Fig. 5). The base of the leaf is decurrent on a broad short petiole, which accordingly appears slightly winged, as in *Andromeda revoluta*, Heer, of the Miocene. The nervation of both species is different.

9. MAGNOLIA ALTERNANS, *Heer*. Phyll., page 20, Pl. iii, Figs. 2, 3, 4.

Two good specimens of this species are in the collection of Dr. Le Conte; one like Fig. 3 of Heer, the other still larger than Fig. 4. They differ from all the specimens and species from the N. Lignitic, by the strong deep secondary nervation, and by the form of the leaves also.

In the general or specific character of these cretaceous leaves there is nothing to force a modification of the remarks made on the fossil plants of the Northern Lignitic. The three first new species are without analogues in the Miocene flora, and the fourth, *Sassafras Le Conteanum*, is of a peculiar type, represented heretofore only by *Quercus Benzoin*, Lesqx., from Nanaimo, Vancouver's Island. This fact, and also the presence of *Cinnamomum Heerii*, Lesqx., in the cretaceous of Nebraska, confirms the opinion of Prof. Newberry, who, from personal examination in place, considers the Nanaimo's deposits as Cretaceous, and those of Bellingham Bay as Miocene.* As the lithological compounds which contain the fossil leaves of both localities are nearly alike, and as both formations have species of the same genera, especially of *Cinnamomum*, I supposed them synchronous, and referred them to the Miocene. For indeed *Cinnamomum Heerii*, of Nanaimo, is of a type as evidently miocenic as *Cinnamomum crassipes*, of Bellingham's Bay. This recalls to mind *Cinnamomum Mississippiense*, of the Northern Lignitic, which, as said above, is

* Description of fossil plants collected by Mr. George Gibbs, by Dr. J. S. Newberry, page 3.

closely related to *C. Heerii.* I copy here the diagram of Prof. Hilgard, which comparatively shows, in *a*, the deposit where this *Cinnamomum* was found, while plants of the yellow clay, Sabal, &c., were collected at *c*.



Section of Lignitic strata at Ragland's Branch.

On this remarkable section the author says: "The stratum of greenish-yellow sand, *a*, contains impressions of leaves chiefly of a *Cinnamomum* not unlike *Sassafras; c* is a bed of yellowish-white clay of irregular, or thickly laminated cleavage, containing numerous leaves of Sabal, also a variety of other, chiefly dicotyledonous plants, which seem to be identical with species found in the red shale of Tippah. In the yellow sand at *d*, immediately overlying the clay stratum, there occur large billets of silicified wood, the interior of which is black. The bed of the branch of the northern half of the bluff is formed by blue clay, *e*, of massy cleavage, similar to No. 1 of sections 18 and 19, which appears to underlie horizontally. The northern dip of the strata of the outcrop seems therefore to be owing to a fault or landslide." As in section 18, mentioned above, the blue clay, *e*, underlies the red shale with plants, I would rather suppose, from this diagram, that the northern dip is due to some local uplift, and that consequently the stratum, *a*, is at a lower station than the leaves bearing clay, *c*. If it is otherwise, and if this bed, *a*, is true Northern Lignitic, we have in its fossil *Cinnamomum* the first and only direct link of connection between this formation and the Upper Cretaceous of Nebraska.

ARTICLE XV.

ON THE PHALANGIA AND PEDIPALPI COLLECTED BY PROFESSOR ORTON IN WESTERN SOUTH AMERICA, WITH THE DESCRIPTION OF NEW AFRICAN SPECIES, ACCOMPANIED WITH A PLATE.

BY DR. HORATIO C. WOOD, JR.

Suborder PHALANGIA.

Family I. PHALANGIDÆ.

Genus Phalangium.

P. Ortoni, n. sp.

Dorsum black, minutely densely tuberculate. Cephalothorax, with its posterior segment distinctly separated from the others, with a distinct membranous transverse line just posterior to the eye-eminence, and a similar one between it and the abdomen. Eye-eminence moderately prominent, with a row of small spines surmounting each eye. Palpi long, slender, yellowish-gray, without spines, slightly pilose, with a well-pronounced blunt process at the distal end of their antepenultimate article. Mandibles of the same color as the palpi, without spines, their last article attached by its end in the usual manner. Abdomen distinctly segmented posteriorly. Ventral surface with the coxæ, blackish, minutely tuberculate. Coxæ with a series of small tubercles on their margins. Trochanters blackish. Legs very long and slender, roughened by small spines.

Length of body, 0.25″. Legs so broken that their length cannot accurately be determined, but the longest are, apparently, nearly 3 inches long. There is in the collection but a single specimen.

Hab. Napo River, Ecuador.

Family II. GONYLEPTIDÆ.

Genus Gonyleptes.

Eyes two. Tarsal joints few in number. Last article of mandibles attached by its end.

G. prædo, n. sp.

Dorsum, with the ventral surface, legs, mandibles, and palpi blackish, divided by a deep V-shaped groove, arising at the positions of the third pair of legs, into two dis-

tinct portions; ornamented with numerous tubercles, which, posteriorly, are arranged in very pronounced transverse series, also with 5 pairs of prominent spines; the most anterior pair of the latter are placed on the eye-eminence; the second and third pairs have their bases elevated; the third pair are much the largest. Eye-eminence very broad, tuberculate, bifid above by a pair of diverging spines. Maxillæ smoothish. Palpi nearly as long as the body, rather slender, roughened by numerous tubercles, distally sub-cylindrical; their penultimate article somewhat dilated, with a pair of long, slender, very acute incurved spines, and several smaller ones on each margin; their last article smoothish, dilated, with slender, very acute, prominent incurved spines on its margins. Ventral surface and coxæ of feet roughened with large numbers of tubercles; the posterior coxæ with a small spine on their posterior upper angle. Posterior pair of legs roughly tuberculate proximally; tarsi 8–10 jointed, hairy, the last joint armed with 3 curved claws. (Pl. 24, fig. 5.)

Remarks.—There is in the collection but a single specimen of this species, a female, I believe. All of the legs are broken off except a single hind one.

Length of body, $\frac{10}{16}''$; hind pair of legs, $1\frac{11}{16}''$.

G. injucundus, n. sp.

Dorsum dark brown, with somewhat of an olivaceous or ferruginous tint. Cephalothorax provided with a row of 3 small greenish tubercles on each side of its anterior margin, and divided by a curved transverse line into two portions; the anterior of the surfaces thus separated, is elevated up to the position where it is crowned with two rather widely separated cylindrical obtuse spines or processes, upon the exterior side of whose bases the two large eyes are placed; the bases of these processes are rather coarsely tuberculate, and the general posterior slope has a pair of patches of large, somewhat greenish translucent tubercles: the posterior of the surfaces is divided anteriorly by a curved V-shaped line, whose point runs into the first line, so that two small islets of surface are separated, in the centre of each of which is an elevated transparent tubercle, similar to those of the afore-mentioned patches, with some small scattered tubercles around it: posteriorly to the last-mentioned line is a similar transverse one, the surface separated by which has some scattered small tubercles, besides a pair of others smaller though similar to and in the same line with the transparent tubercles above mentioned; the sub-surface posterior to the last-mentioned impressed line, has a very large, prominent pair of divergent robust spines and minute scattered tubercles. Palpi, chestnut brown, very roughly tuberculate. Mandibles, chestnut brown, with a curved, acute, robust, short spine on the upper surface of their penultimate article at the margin of the cephalothorax; their last article robust,

very hairy, attached by its end and bent downwards. Abdominal segments with unequal, obtuse spines or tubercles. Ventral surface and coxæ minutely tuberculate. Feet distally pilose. (Pl. 24, fig. 9.)

Length of body, 0.30″ inch. Length of posterior legs, about 1¼ inch.

Remarks.—There is but a single specimen in the collection.

Hab. "Between Quito and Napo," Ecuador.

G. spinipalpus, n. sp.

Dorsum a dark, blackish brown. Cephalothorax not generally granulate, provided with a somewhat distinct but here and there obsolete impressed line some distance within and sub-parallel to its margin, which separates a central, oval, elevated part from the more level margin; also divided by a deeply impressed curved line some distance posterior to the eye-eminence and by an obsolete, subparallel line posterior to this; the anterior portion with a pair of widely separated, small, tuberculoid spines; on the posterior surface, anteriorly, a transverse series of similar tubercles or spines, the middle pair of which are, however, much larger; then a second similar, but uniform series; then a pair of very large spines flanked by one or two tubercles, and posterior to these five tubercles in two rows. Eye-eminence oval, broad, transverse, with a largish blunt spine and one or two very small ones surmounting the eyes. Mandibles large, their penultimate joint sub-globose, with a few small, slightly curved, robust, acute, thornlike spines; their last article robust, smooth, with rigid spine-like hairs, attached by its end, but so bent as to hang vertically. Palpi long, rather robust, proximally sub-cylindrical; their trochanters with a few very blunt spinous processes; their penultimate article dilated with five unequal, long, slender, acute spines on elevated bases on the inner margin, and two very long and two very small similar ones on the outer margin; their last article slightly spoon-shaped, with four spines similar to the last on each margin. Abdominal scuta with a row of tuberculoid spines on each; the abdominal segments below tipped with whitish, each with a series of minute granules. Coxæ roughly granulate, the granules often disposed in longitudinal series; the last pair rather small for this genus. Legs granulate, of a lighter color than the body, their tarsal portion very hairy. (Pl. 24, fig. 6.)

Length of body, 0.25″; of first pair of legs, ?; of second ?; of third, 0.9″; of fourth, 1.10″.

Remarks.—A single specimen in the collection.

Hab. Ecuador.

G. multimaculatus, n. sp.

Dorsum, glossy black, very minutely tuberculate; just posterior to the eye-eminence, with a broad, transverse, bright-yellow band, the posterior portion of which has a central, broadly triangular extension; all the rest of the surface closely dotted over with minute, roundish, whitish spots, which are, also, although fewer, on the inferior surface and coxæ. Eye-eminence very broad, with numerous, very minute tubercles. Palpi and maxillæ? . Coxæ and pectus roughly tuberculate. (Pl. 24, fig. 10.)

Remarks.—There is in the collection but a single, very much mutilated specimen of this species. The body is nearly a third of an inch in length,

The locality label reads: "Napo and Maravon."

GENUS ORTONIA, new genus.

Eyes, two. Last article of the mandibles reniform, attached laterally by its centre. Tarsal joints of second pair of legs very numerous. (Pl. 24, figs. 3 a, 3 b.)

Remarks.—I have dedicated this genus to Prof. Orton as an acknowledgment of the services rendered by him to Science by his arduous and successful journey in South America.

O. bilunata, n. sp.

Cephalothorax reddish-brown, its anterior margin doubly crescentic, with an acute point in the centre, provided with a pair of large sub-elliptical light yellow spots, whose margins, especially the inner, are irregularly waved or crenate, and, anterior to whose centre, in each is a marked puncture or depression; between the posterior ends of these maculae, is a pair of prominent, long, divergent, slender, but rather obtuse, reddish-brown spines; general surface smoothish, with a velvety appearance. Eye-eminence smooth, broad, longitudinally grooved in the centre so as to be almost double, with the eyes placed laterally on its most prominent portions. Distal joint of maxillæ reniform, beautifully areolated, smoothish, the antepenultimate joint sub-globose, with rather prominent spinous processes on it externally. Palpi, with the proximal joint sub-cylindrical, long, and slender; the next joint broad, slightly triangular in section, its edges roughly crenulate, and the penultimate joint broadly dilated, somewhat triangular, thin, and armed with minute, slender spines on its margins, and a pair of larger ones on its distal end; the distal article more cylindrical, with one or more acute spines, against which the movable claw works. Ventral surface of the color of the upper, with the abdominal segments distinctly bordered with a light color. Legs reddish-brown, with some small spines or tubercles;

the first pair with the tarsal joints, eight in number, swollen; the third, with about twelve tarsal joints scarcely swollen. Coxæ smoothish, the last pair not very large. (Pl. 24, fig. 3.)

Length of body, 20″; of first pair of legs, 1.00; of second pair, 2.40″; of third pair, 1.5″; of fourth pair, ?

Remarks.—A single specimen in a bottle containing several species, and labelled "Ecuador, except one from Peru."

O. ferox, n. sp.

Dorsum light reddish-brown, provided on its posterior portion with a very long, slender spine, whose base is somewhat tuberculate, and whose length almost equals that of the dorsum; anterior to this spine is a pair of large umbonations or obtuse elevations, surrounded by a marked groove or furrow, on which are two or three small eye-like tubercles. Eyes very widely separated, each on a pedicle-like eminence. Placed centrally, and a little in front of the eyes, occupying about the position of the usual eye-eminence of the phalangia, is a marked, conical elevation surmounted by two or three eye-like tubercles, and having several similar ones scattered about its base. Distal joint of the maxillæ reniform, laterally attached, presenting a very narrow face or obtuse edge anteriorly. Palpi nearly three times as long as the body, very slender, excepting their two distal joints, which are so flattened as to present a broad, inferior face, and are armed on each of their two edges, the one with five or six long, moderately-robust, curved, very acute spines, the other with about three similar spines and several smaller ones; the movable finger very long, curved, acute, so moving as to play between the rows of marginal spines against the broad surface. Pectus and coxæ with rows of large tubercles. Last pair of legs about an inch and a half long, very slender. (Pl. 24, fig. 8.)

Remarks.—The legs of the only specimen I have seen, are so broken that it is impossible to determine the generic characters. The agreement, however, in general appearance, in the wide separation of the eyes, in the last article of the maxillæ, &c., with O. bilunata, have induced me to class the species together. The specimen is labelled: "Napo and Maravon," indicating its having been taken, I suppose, in journeying from one place to the other.

Octophthalmus, new genus.

Eyes, four on each side of the eye-eminence. Last article of mandibles attached by its end. Tarsal joints ?

O. marginatus, n. sp.

Cephalothorax dark reddish-brown. Margin provided with a double greenish-gray band (alcoholic specimen), which, posteriorly, involves the whole of the abdominal scutal segments, where it is interrupted by a central band; the surface divided into two portions by a deep transverse groove at the position of the third pair of legs; the anterior surface thus formed smooth; the posterior divided again into three parts by two transverse lines, the anterior of which communicates with the first line by a central longitudinal line, so as to form two little squarish islets of surface, in the centre of which are one or more small tubercles; the surface between the second and third line furnished with several tubercles arranged in a transverse series; posterior to the third line is a pair of very prominent, large spines, whose surface is minutely tuberculate. Eye-eminence double, smooth, low, with four (two light-colored, two blackish) eyes on each side. Maxillæ with the last joint large, areolated, attached by its end. Palpi ?. Ventral surface smoothish. Coxæ minutely roughened. Posterior pair of legs minutely tuberculate on their femora. (Pl. 24, fig. 7.)

Length of body, $\frac{3}{16}''$.

Suborder PEDIPALPI.

Genus Phrynus.

P. gorgo, n. sp.

Dorsum blackish-chestnut, roughened with minute tubercles. Cephalothorax reniform, truncate anteriorly, with its margin elevated and obsoletely crenulate. Anterior eyes situated on an oval eminence, which is truncated above. Palpi long and slender, with the maxillary process at their base pronounced; their trochanters irregularly triangular, with three more or less distinct faces; on the inferior of these, near its anterior margin, is a more or less distinct obsoletely crenulate ridge, terminating anteriorly in a robust, moderately large spine, and, posteriorly, in a robust, blunt, dark-reddish chestnut, cylindrical process, tipped with a light, reddish-brown; there are two or three other spines on the ridge separating the anterior-superior from the inferior face; the anterior-superior face is separated from the posterior by a more or less pronounced crenulate line: the femoral article sub-cylindrical, sparsely tuberculate; its superior-anterior edge with three large unequal spines on its proximal part, and one or two smaller ones placed more distally; its inferior-anterior edge with four large (two very large), unequal proximal spines, and two smaller, more distal ones: tibial or penultimate article sub-cylindrical, granulate as the last; its anterior-superior margin with three immense distal spines and two very small ones, also with one or two moderate, more proximal ones; its anterior-inferior margin with five unequal spines on its distal

two-thirds, of which the third (counting from behind forwards) is much the largest; its last article sub-cylindrical, with a curved, acute, movable claw, and a pair of basal, curved, very large spines, each with a small spine at its base. Legs roughened with somewhat acute granules. (Pl. 24, fig. 1.)

Length of body, 1.15″; of palpi, 2.5″; of first pair of feet, ?; of second pair, 3.25″; of third pair, 3.75; of fourth pair, 3.50.

Remarks.—This species was, with others in a bottle, labelled: "Peru, except one from Quito," and, as there were two specimens of it, probably came from the former country.

AFRICAN SPECIES.

Phrynus annulatipes, n. sp.

Dorsum, brown, mottled. Cephalothorax broadly reniform, somewhat truncate in front, with a central depression and more or less obsolete radiating lines, roughly granulated. Eye-eminence roundish, black. Abdomen roughly tuberculate, with a longitudinal, central crest, which is not pronounced. Legs light brown, annulate with dark brown; their trochanters and femora, roughened by numerous, bluntish, spinous tubercles, many of which terminate in a rigid hair. Palpi robust; the coxæ roughened with numerous tubercles, their opposing edges with numerous long, slender, hair-like spines, the mandibular process pronounced; trochanters with numerous acute, robust, small, thorn-like spines obscurely arranged in three patches, also armed with three or four similar larger spines; femoral article sub-cylindrical, with a flattened anterior face, everywhere roughened by small, often hair-bearing spines, armed—on the anterior-superior margin with four largish and numerous very small spines, two of the former are close together at the proximal end—on the anterior-inferior margin with five largish spines and numerous very small ones, two of the former on the proximal end; tibial article of similar form and roughness with the last; the superior anterior margin with numerous very small, and one or two rather small spines, and a pair of very large tuberculate spines confluent at their bases, on its distal end; the anterior-inferior margin, with numerous very small spines and four small spines, the most distal and largest of which is on the end of the article; last article somewhat cylindrical-conical, roughened as the last, with a pair of large spines directed forward, and a smaller, robust spine at the base of the upper of these directed backwards. Mandibles tuberculate on their upper surface. Ventral surface smoothish. Ligular process bifid. (Pl. 24, fig. 2.)

Length of body, 0.66″; of palpi, 1.″; of first pair of feet, 3.6″; of second pair, 1.4″; of third pair, 1.55″; of fourth pair, 1.6″.

Remarks.—The specimens on which this description is founded, were collected in the Zulu country, South Africa, by a missionary, Dr. A. Grout, and presented to the Academy of Natural Sciences, in whose collection they now are.

Buthus Groutii, n. sp.

Cephalothorax very smooth, blackish, with a marked, longitudinal, light yellowish-brown, median line, and a similar one on each lateral margin; its median keel slight; its anterior margin not truly emarginate, although there are some indications of emargination. The three lateral eyes about equal. The arms light yellowish-brown, pilose, without spines or pronounced crests. The hands blackish, smooth, somewhat tumid, with the fingers slender, elongated, brownish, and each with numerous teeth placed closely in oblique series. The tail rather robust, very smooth, and polished; its upper surface very deeply furrowed, and with the lateral margins of the proximal four short, light-brown articles, prolonged upward into a very strongly marked spinous process; its under surface without crests, whose ordinary position, however, is marked by dark lines; the penultimate article the largest, blackish, deeply furrowed above, but without spines or pronounced crests; the last article blackish, pilose, somewhat ovate, flattish above, tumid below; the sting slender, strongly curved, with a minute tooth or spine at its base. The legs light brown, mottled above with black. The combs with about fifteen teeth each. (Pl. 24, fig. 4.)

Length of body, 0.45″; of body and tail, 1.25″.

Remarks.—I have seen a single specimen of this species, a male, belonging to the Academy, collected by Dr. Grout in the Zulu country, South Africa. I have named it in recognition of the services of Dr. A. Grout, alike to humanity and science.

ARTICLE XVI.

REMARKS ON THIRTEEN NEW SPECIES OF CRINOIDEA FROM THE PALÆOZOIC ROCKS OF INDIANA, KENTUCKY, AND OHIO, AND A DESCRIPTION OF CERTAIN PECULIARITIES IN THE STRUCTURE OF THE COLUMNS OF DOLATOCRINUS, AND THEIR ATTACHMENT TO THE BODY OF THE ANIMAL.

BY SIDNEY S. LYON.

Read, February 19, 1869.

THIRTY years have passed away since the collection was commenced which is now the subject of this paper.

The rocks outcropping at the water's edge along the Falls of the Ohio, have become extensively known to geologists and collectors of fossils.

One of these beds has become known as the (Olivanite bed) Nucleocrinus bed, or more commonly as the Hickorynut bed. The entire thickness of this bed, in the greatest expansion observed, is about four feet; from this thickness it diminishes to a knife-edge, and at many localities it thins out entirely and disappears.

This horizon is the place of *Nucleocrinus Verneuilli*, *Nucleocrinus angularis*, *Dolatocrinus lucus*, *D. glyptus*, Hall (if the identification made is correct), *Magestocrinus spinusolus*, *Poteriocrinus simplex*, and *Poteriocrinus cylindricus*, *Actinocrinus penta-spinus*, *Actinocrinus multicorula*, of this paper; also three species referred to a new genus, HADROCRINUS, and described in this paper. There have been found three or four other species not identified, probably new.

At the quarries on Bear Grass Creek, Jefferson County, Kentucky, the crinoidal bed above referred to has become quite thin, or has entirely disappeared. Above its place is a bed of hydraulic cement stone, from four to eighteen inches in thickness. At the foot of the Falls of the Ohio, the cement bed has increased in thickness, and it is at this last-named locality about nineteen feet thick.

Succeeding the hydraulic beds is situated a bed of shaly limestone, from six to eight feet thick, containing a large number of crinoidea, but none of those before enumerated have been identified as occurring in it. In this last bed have been observed and identified, *Dolatocrinus Troosti* (*Cocabiocrinus Troosti*), *Dolatocrinus liratus* (*C. liratus*), *Dolato-*

crinus liratus var. *multilira* (*C. l.* var. *multilira*), *Dolatocrinus* var. *intermedius* (*C.* var. *intermedius*), *Ancyrocrinus bulbosus:* all the above are Hall's species. *Enletherocrinus Cassedayi, Actinocrinus Cassedayi, A. Kentuckyensis Cyathocrinus sculptus, C. valens, C. leviculus,* and others; and several new, or not identified with any description.

Pentremites of the carboniferous type, intermediate between *P. florealis* (*Godoni*) and *P. pyriformis,* Say, are obtained in this bed. These have not been identified.

At the Bear Grass Quarries, where the covering of the lower horizon of crinoideans are separated by the thin layer of hydraulic limestone, there is a partial mingling of the crinoidea of the two beds separated by it. *Nucleocrinus Verneuilli* are found in the upper bed. They are smaller, less robust, and differ very considerably from those obtained in the bed below the hydraulic limestone at the Falls of the Ohio.

From the year 1835 until 1867, fragments from the Nucleocrinus beds were added to the collections made from year to year. They were generally parts of crinoidal bodies of large size, pieces of bases, fragments from the middle of the body, fragments of the dome-covering, &c. Until 1867 no specimen revealed the true structure of the calyx of any of the species. No arms or parts of arms have ever been found attached to any of the species. Columns of very large size, short, rapidly tapering from below upward, having many side branches; often found clasping the column or other bodies, are associated with these remains. These are provisionally referred to H. plenissimus. They do not belong to any species of Dolatocrinus. The column has been found attached to the largest species found in the horizon in which it occurs, and to many of the smaller species of Dolatocrinus occurring either in the lower or upper beds; all these are of an entirely different type. In the general form and surface-markings, it most resembles Dolatocrinus, associated with it in the same bed. The base of all the species known are deeply excavate. In Hadrocrinus plenissimus the basal pieces are entirely hidden under the columnar facet. The first radials, and part of the first radials of the second series, and the interradials of the first series, are deeply implanted in the basal pit, or included within its margin. No specimen that has been observed exhibits the basal pieces, if seen from the outside of the specimen. All fragments, properly cleaned, that contains the base of the animal, will show the structure of the base, seen from the inside.

The first radial pieces are very large. In H. plenissimus they differ greatly, both in size and form. They all appear to be ray-bearing. No irregular side, analogous to the *asygos* (anal) side, has been seen in any of the examples observed.

It is no slight matter, in the present condition of our knowledge respecting these animals, to decide what may be differences of structure that have true generic significance. These bodies will not fall into any genera as now defined. The general aspect is different from all known genera and species that have been observed.

It is believed that the differences existing between these and any known crinoidal bodies, are at least of sub-generic importance, even if they are not of greater value. It is therefore proposed that these bodies be classified and distinguished under the generic name of Hadrocrinus, and the following generic formula is proposed.

(*Ἁδρὸς*, full grown.)

HADROCRINUS, *n. g.*

Generic Formula.

Basal pieces, ...	3.
Radial pieces, . . .	1st series, 2×5, first large, second cuneiform.
Radial pieces, . . .	2d series, 2×10, second cuneiform.
Radial pieces,* . . .	3d series, 2×20, " "

Other divisions of the rays advance in series of two.

Interradial fields five, composed of three pieces or more, usually long and narrow. The first resting in the notch between the first radials.

Interbrachial fields two to four pieces or more; irregular; fields differ in different species.

Column round, rough, tapering rapidly, and bearing many branches; opening at top of column round; at some distance below the calyx penletotate. Anal† field. (?)

RADIATA.

ECHINO-DERMATA.

CRINOIDEA.

HADROCRINUS PLENISSIMUS, *n. s.*

Pl. XXVI, Figs. b, b 1, b 2, b 3.

The specimen figured and described is slightly crushed, and does not exhibit the true form. The true form, making due allowance for the crushed condition of the specimen, was low and vase-like; the upper part, above the arms, as shown by other specimens,

* Some species may be found which do not extend to the third bifurcation of the ray-bearing pieces. Our specimen of H. plenissimus extends further than the formula. H. discus only bifurcates regularly twice. The formula is intended to receive all crinoids with only two ray-pieces in the primary series.

† It is not certain that there is any such difference in the sides of the body as that heretofore called the anal side. The difference spoken of in the size and form of the large first radial pieces, may distinguish the anal side.

gradually rose from the arm-bases about half of the height of the dome; then, more rapidly, about one-third of the height, when the curve of elevation was gradually reversed, and the summit of the dome rounded into a form sub-hemispherical.

The cicatrices, showing the location of the arms, form a closed zone around the calyx at the point of its greatest diameter. In this arrangement of the arms, it resembles Botocrinus. Below the arms, the calyx is depressed vasiform; the base deeply excavate for the reception of the column, which covers and completely conceals the basal pieces. These are not visible from the outside of the specimens, even in the absence of the column.

Basal pieces three in number; when detached from the body present a shallow cup; the interior surface is rounded by the considerable thickness of the pieces, having five angular points, and five concave depressions between them; the spaces which cross the junction of the pieces with each other, being deeper than those upon the ends of the two large basal pieces. The centre of the base has a deep hemispherical depression around, and including the opening between the body and the column; the parts of the basals around this opening are quite thin; the main body of them are remarkable for their thickness. Well-preserved specimens are marked with a leaf-like depression, which originate around the opening, and extend toward, and terminate near the five points of the margin of the base. *First radials;* five in number. Compared with the other pieces forming the body, they are very large, resting on the basals, and extend downward and outward; joined to each other and the base, they form a deep cup. They vary in size, and differ in form: three are hexagonal, the two largest pieces are sub-septagonal—having two angular prominences on the summit of each—the other three are squarely truncated at their superior extremity. The *second radials*, of the first series, are comparatively small. These rest against the square ends of the three smaller first radials, and in the notched space at the summits of the two irregular first radials; they are pentangular, cuneiform, and support, each, two radials of the second series. The second piece of the radials of the second series is also cuneiform, and support each two radials of the third series. The rays are again divided on the second radial of the fourth series. There are other divisions of the radials; these are not sufficiently marked for description. Our specimen probably had eighty rays. It is not improbable that the number of free rays increased with the growth of the animal. Some fragments evidently of the same species as this under consideration, show distinctly the fourth division of the radials upon the body and below the free rays. If the rays bear an equal number of free arms, on the fourth division there would be $5\times2=10\times2=20\times2=40\times2=80\times2=160$.*

* Fig. 62, pl. xxvi, was taken from a specimen in the collection of Dr. L. P. Yandell, who, for the purposes of this description, has kindly placed his cabinet at my disposal.

This specimen is figured to show the arrangement and proximity of the arm-bases. If the curve

Interradial fields.—These are five in number, of about seven pieces each. The first piece rests in the angular notch between the first radials; these support two; those two others upon the summit of the third range, in a notch between the pieces, rests the sixth piece of the interradial fields; the sixth supports upon its upper oblique margin a seventh piece, which rests also against the first piece of the second division of the rays. There is some irregularity in this arrangement; some of the interradial fields carry the seventh piece of the field with the double series, and close the series with a single piece; in these cases making eight the number of pieces forming the field.

Interbrachial fields.—Between the first divisions of the ray are placed two pieces, one above the other; they are entirely enclosed by the pieces forming the first and second divisions of the rays. A single piece is placed above the second division of the rays, and is enclosed by the pieces of the second and third division of the radials.

The pieces composing the rays, interradial and interbrachial fields, are nearly equal in size, and are so placed that they form entire zones around the body; nine such zones are apparent in the fragment figured. Other fragments, from portions of the body near the arms, show several more.

The surface of the pieces forming the calyx are variously ornamented, depending upon the condition of the animal at the time it was buried. The best preserved specimens show that the animal had a thick covering different from the bony skeleton, rising in well-defined lines; on this substance are bands of from six to two elevated ridges (most numerous on the pieces near the base), that cross the body in every direction, crossing each other at the centre of the pieces. Near the free rays the bands are reduced in number, and the centre of the subdivisions of the rays are ornamented by an elevated ridge or carina, very thick and high for the size of the pieces which they cover; the summit or back of the carina seems to be plain or level; these ridges are slightly increased in width at the centre of the pieces, which are crossed at right angles to the direction of the rays, by other carina nearly equal in height to the first, and about half as wide as they are. In weathered or worn specimens, that show the naked surface of the bone of the plates, the entire surface of the pieces are covered with a network of fine ridges and depressions, having the general direction of the ridges before described. The ridges frequently bifurcate and close again, filling the surface of the pieces with irregularly-shaped pits or depressions. So varied are the surface-markings growing out of the different conditions of the surface, that were surface-markings relied upon as a specific difference, many species would become necessary for this species.

found in this fragment be carried to a complete circle, one hundred and twenty arm-bases of equal size to those upon it, would be required to fill the circle. Many fragments have been observed that are part of bodies nearly or quite one foot in diameter; this specimen is about four inches in diameter.

Size of Specimen.

	INCHES.
Diameter across at the base of free arms,	5.50
Height (approximately),	2.08
Height to summit of first radials,	.60
Diameter at summit of first radials,	1.30
Height of dome above free arms (?),	2.00

Fragment, Different Specimen.

	INCHES.
Height to summit of first radials,	2.50
Diameter at summit of first radials,	2.39

Locality.—Lower crinoid bed, Falls of the Ohio, Clark County, Indiana, one mile below Jeffersonville.

HADROCRINUS DISCUS, *n. s.*

Pl. XXVI, Fig. a.

Our specimen is slightly crushed, but it is manifest that it was low and flat, as the crushing to which it has been subjected has not fractured the plates, and only slightly opened the sutures, where they were united one to another. It was found in place in the rocks, resting on the base, the upper part of the calyx breaking out slightly rounded or nearly level. The general form is that of a flattish dish, to the second bifurcation of the radial pieces, from which it rises rapidly upward and outward the length of two radials, when it again expands more rapidly. The basal pit is excavate, but in our specimen the basal and first radials only are included in it. The second radials of the first series, and the other pieces connected with the first radials, are slightly pressed upward. This is probably due to the pressure to which it had been subjected. The specimen had lost the covering above the arms. All observed fragments of this species showing any part of the dome covering, are flattened. The precise form above the arms is unknown. The amount of displacement of the pieces in our specimen, is proof that it was very slightly convex. The base is hidden under the first radials and the remains of the column, and are relatively smaller than those of *H. plenissimus*. The first radials, five in number, are nearly of the same size and form: hexagonal, squarely truncated above; on the square summit rest five radials of the first series; four are pentangular, the fifth piece is hexagonal. These pieces are cuneiform above, and support two radials each, of the second series, upon their upper oblique margins. The hexagonal second radial of the first series also supports, on its sixth side, one of the interradial pieces. The first radials of the first division vary greatly in size and form; they are also much larger than the second piece of the first radials im-

mediately beneath them. They are pentagonal, hexagonal, and septagonal. All these forms are found in some one or more of them. Each of these support another radial of the second series. These also vary in form and size: some of them are subquadrangular, others pentagonal or hexagonal. The rays again bifurcate on these pieces, each of which supports two large pieces, some of which are very large. The rays are continued by two large pieces which reach to the base of the free rays.

The *interradial fields* are five in number; they have a general resemblance one to the other, with many special differences. No two of them are exactly alike. The pieces composing them, like those of the rays, vary in size and form. The first piece of these fields rests in the angular notch between the first radial pieces; these are octagonal; four of them support two pieces, and one, the largest of them, supports three pieces of the next series; these again support two arranged irregularly, and are continued by a series of two rows of small pieces. One of the interradial fields show six or eight pieces; the last are very small, long and narrow, probably connecting with the covering—at least reaching to the arm-bases.

Interbrachial fields.—Those seen on our specimen are formed of two or three pieces. Some of them are formed of three pieces, one above the other; the inferior piece resting upon the summit of one of the first radials of the second series, wedged between the adjacent branches of the ray; the upper piece has a square truncation upon the summit, and appears to support one or more narrow pieces. One of these spaces shows this arrangement of the pieces.

Free rays.—The number of the free rays are not absolutely made out. The division of the rays, on the body of the calyx, indicate that each primary ray bears four rays, or twenty rays in all.

The summit, as shown by a fragment (evidently of this species), is covered by very small pieces, slightly convex; arranged irregularly; or, as on some portions of it, around a central piece which supports a short, blunt spine.

Column round; opening unknown.

The surface-markings upon the pieces in our specimens are quite fine or indistinct. Under a strong lens, those pieces upon which the markings are seen, are covered with fine parallel striæ, parallel with the length of the pieces. The pieces composing the rays are deeply pitted near the centre of them by two very distinct pits; the other pieces with a single one. This marking is so peculiar, that a single plate of this species is certainly known and referred to it. The rays can be traced by the double row of pits which mark the pieces composing them.

Well-preserved specimens will, doubtless, show a beautifully-marked species.

Size of Specimen.

	INCHES.
Diameter at the base of free rays,	3.75
Diameter of pit at summit of first radials,	.70
Depth of basal pit,	.20
Height to free rays,	.70

Locality.—Nucleocrinus bed, Falls of the Ohio, one mile below Jeffersonville.

The arrangement of the arms in groups is somewhat like *Dolatocrinus*. The size of the species is remarkable. In surface-markings it resembles some of the species of *Magestocrinus*, found in the upper crinoidal bed. The plates composing the calyx are very thin, considering the great size of the specimen. It is smaller and less robust than H. plenissimus. The many distinct peculiarities of this species will readily serve to distinguish it from all other crinoideans.

Hadrocrinus pentagonus, *n. s.*

Pl. XXVI, Fig. c.

Of this species only a single fragment has been obtained. The specimen consists of the basal, and first and second radials of one ray. It most nearly resembles H. discus above. The basalar pit is pentangular; basal pieces quite small; the sides of the first radial pieces diverge slightly, making the sides of the pit very steep; the exterior surface of the first radials are swollen outward near their junction with the pieces above them; are subquadrangular; the truncation of the upper outward corners is very small, producing a very small angular depression between the pieces, at their junction with each other. The upper edges of the first radials are beveled upward and inward. Upon these beveled edges are placed the second radial, in a line nearly at right angles with the column; they are pentangular (the one seen is of this form), cuneiform, narrow, lateral margins nearly parallel with each other, and by their manner of joining the first radial, the spaces between them are nearly or quite as large as the pieces themselves. All the pieces composing the base are remarkable for their stoutness, and for the singular manner by which the second radial is joined to the first.

The surface within the pit is well preserved, and shows the markings on the first radials; the surface of the pieces are corrugated by five irregular, rounded ridges, which cross the pieces, and by a multitude of fine lines (furrows), which cross the ridges at right angles with their length; the furrows between the ridges are smooth. The furrows do not cross them distinctly marked, but gradually fade as they approach them.

The single second radial of the first series is very rough, marked by high, interrupted ridges crossing it toward the centre of the adjoining pieces.

The markings upon the first and second radials separate this from the preceding species. Our specimen is of an individual a little less than H. discus. It differs from that species in the pentangular pit, and the more robust character of the plates.

The column appears to have been round, or subpentangular at its junction with the body.

Size of Specimen.

	INCHES.
Greatest length of first radials,	.62
Least length of first radials,	.47
Height of first radials (vertical),	.25
Diameter of base,	.37

Locality.—Same as last.

Notice of some Peculiarities in the Structure of Crinoidal Columns, and the Attachment of the Column to the Body of the Animal.

Pl. XXVI, Fig. h.

In a great variety of crinoidal columns, referred to many genera and species, the attachment of the column is by a simple disk, having a plain or crenulated surface at the points of attachment to the body; the disk, by which the column joins the body, being the last joint of the body. Usually the disk is crenulated, varying in the character of the markings with the genera or species to which it belongs; sometimes the marks are only on the margin of the disk; in other species the striæ covers the entire surface of the place by which it attaches to the body; in some the lines are straight, in others wavy or zigzag.

In columns found attached to the bodies of several species of *Dolatocrinus*, the whole structure and arrangement of the superior extremity of the column differs from the forms referred to in a remarkable manner.

In one specimen, in which this variance from the usual form is clearly and distinctly seen, the column is round from a point half an inch below the calyx. In the specimen, the round disks composing this part of the column are about twelve in number, with twelve thin muscular (?) pieces between them,—the number varying with the age of the animal. The round disks, forming the plain part of the column near the calyx, decrease in size, descending about one-half of the pieces, when they increase slightly for the lower portion. On the superior plain disk of the column are placed about ten pieces (varying in number), rapidly increasing in size as they ascend—alternately thick and thin pieces.

The uppermost of these is the largest, expanded at five points around its margin, producing a pentangular piece. The extremity of the angular corners are greatly thickened upward and downward, joined so that the two adjacent, large, thickened pieces completely enclose and cover the thin pieces which lie between them at that point; the smaller and thinner pieces only appearing between the enlarged points of the thick pieces. In very old (matured) specimens the thick and thin pieces are about ten—five of each class. In this case the thick pieces have so increased in thickness as to entirely cover the thin pieces lying between them. Sometimes cases are seen when the thicker pieces have increased to nine. When this is the case, one side of the column has the additional thickened pieces on one side of it. The large pieces then are very thick, and are implanted upon the thin ones, covering, by their breadth, from four to six of them; the thickened edges of the large pieces forming five carina, along the length of the column, above the supplemental pieces.

Below the smooth, rounded disks forming the column, they are alternately thick and thinner. The thick pieces have bosses or enlargements upon them, from three to five each piece, of the same model as those upon the thickened pieces at the upper extremity of the column (not so large as they are, nor so prominent); between these bosses are from two to six much less prominent—straight at the junction of the pieces with each other. The large ones are most prominent in the centre of the thickness of the pieces upon which they are placed.

Between the thick and thinner pieces of this part of the column, are still thinner disks, not seen in an unbroken column; very distinct when the column is separated. This class of disks is supposed to have been muscular, and not bony, or like the larger pieces between which they are placed.

Resting upon the upper joint of the column—the largest piece in the column—are about nine thin disks or zones; the opening of the column, which passes through these, being equal to half the diameter of the largest of these pieces; they diminish gradually in circumference, rounding the pile to a hemispherical form; the upper zone by the opening in the column, and its diminished size, is reduced to a ring about as wide as high. The bottom piece of those composing the hemispherical (*atlas*) at the head of the column, joins the upper piece of the column, the surface of both pieces being sharply crenulated upon the joining surfaces. Surrounding the hemispherical pile of thin pieces at the head of the column, are three (?) or five false basalar pieces. These pieces rise above the top of the pieces of the atlas a distance equal to the thickness of two of the zone-pieces enclosed by them; they terminate upward, in a thin knife-like edge, around the columnar opening; their broad, external faces fitting into the columnar pit, partly sunk in the basal pieces, and partly enclosed by and fitting the external surfaces of the inferior extremity of the

first radials. The inferior extremity of the false basals are about as thick as the width of the lowest zone forming the atlas; they are joined by a crenulated surface to the upper disk of the column, thus completing it in a rounded hemispherical knob, composed of the two sets of pieces described, the whole completely filling the lower part of the depression at the base of the calyx of the animal.

The pieces terminating the column are divided like the true basal pieces; they form a similar cup, not notched, as are the summit of the true basals, but squarely truncated and crenulated at their base, like the pieces composing the column below the body.

The pieces rounding the top of the column are frequently found attached to the body, completely filling the basalar cavity. They can generally be distinguished from the upper flat disk of the column, by the difference in the texture of the two classes of pieces, and are usually seen as two rings, one within the other.

All the deep, basal-pitted Dolatocrinus known, are attached to columns, the summits of which are formed in the manner of those described above. No columns of the class described have been found attached to any species of Hadrocrinus. The basalar pits, and the rounded indentation in the true basal pieces, are formed in the same manner in Hadrocrinus as those of Dolatocrinus, to which they have been found attached.

Several species of Dolatocrinus, to which this form of the head of the column is known to belong, have the column below the *atlas* formed of alternate broad and narrower disks. The muscular attachments are not so distinctly marked upon the exterior surface of the atlas, as in the large species *D. glyptus* (Hall's species), to which the columns particularly described belongs. No opinion is offered in relation to the particular use of the head of this class of columns of crinoidea.

It is proposed to distinguish the pieces forming the exterior covering of the head of the column, *false basals;* and the whole dome-like termination of the column, the *atlas.*

Genus ACTINOCRINUS. Miller, 1821.

(*Nat. Hist.* Crinoidea.)

Actinocrinus pentaspinus, *n. s.*

Pl. XXVII, Figs. d, d 1.

Body, when divested of the summit covering, sub-cylindrical; slightly contracted beneath the arm-bases; base squarely truncated parallel to the arm-bases; the united basal pieces are pentangular; a little larger than one of the first radials; a piece of the column attached is small and round, formed of circular pieces of variable diameter, the larger pieces thinning from their junction with the smaller ones, and terminating in a sharp edge. The

basal pieces are remarkable for the perfectly level inferior surface, except at the points, which are slightly elevated. The first radials are very large, each bearing near its centre a stout spine, nearly half an inch in length, which is pointed outward and upward. Three of the radials are hexagonal, two subseptagonal—differing slightly in size. Each bears a second radial, of variable size and form: two are pentangular; three subquadrangular; some are plane-surfaced, others are slightly convex. The third radials are very small; differing in size; pentangular; some of them are so short as to appear triangular; these are about five times as wide as high; they support one or two circular or crescent-shaped pieces; these, the bases of the free arms, ten in number. Their form and arrangement are unknown.

From the notch between the sides of the first radial pieces, rise five interradials of the first series, variable in size and form; the largest are hexagonal, the others subquadrangular; they each support two interradials of the second series; different in form and size; small. The third series of interradials are very small; one or two to each field; their upper extremity extending upward between the groups of arm-bases. The arm-bases of each group are quite close to each other, but they appear to have a slim, long piece between them.

The covering of the dome is absent; its form, and the arrangement and character of the pieces covering it, are unknown.

This species, as seen in our example of it, does not show any surface-marking on the plates; they have, no doubt, been lost from our specimen by the loss of the integument which covered their surface.

Size of Specimen.

	INCHES.
Height to free arms,	.60
Diameter at free arms,	.70
Diameter to end of spines on first radials,	1.50
Diameter of united basal pieces,	.40
Diameter of first radials,	.35

Locality.—Nucleocrinus or lower crinoid bed, Falls of the Ohio; very rare as good specimens; plates and fragments not rare.

This species has many of the characters of Dolatocrinus. It is not nearly related to any known species of Actinocrinus, except *A. multicornus*, described in this paper. It will be readily distinguished from all Actinocrinus, by the spines, which rise so prominently from the first radial pieces.

Actinocrinus multicornus, *n. s.*

Pl. XXVI, Fig. e.

The body swells gradually from the arm-bases to the summit of the first radials; then diminishes by a similar curve, to the bottom of the first radials; below this point the body is unknown; the structure or arrangement of the species is nearly identical with A. pentaspinus. The arm-bases are not quite so prominent as in that species. The first and second radials, and the first interradials, are all spine-bearing. The spines on all the spine-bearing pieces, are of equal size—short, stout, and pointed. The spines upon the first radials rise less abruptly from the face of the piece than the others; the piece is also more gibbous than the other spine-bearing pieces.

The summit is crushed and the pieces disarranged. Among the disarranged pieces, upon the summit, are some bearing strong spines; nearly of the same form as the spines upon the body. The arms are in groups of two for each ray—ten in all. Their form and arrangement is unknown.

The form is more delicate than A. pentaspinus, which it more nearly resembles than any other known species. The points of the spines are not so acute as they are in that species, and none of them are large or long.

Size of Specimen.

	INCHES.
Diameter of body to points of spines,	.80
Height to top of arm-bases,	.54
Diameter of body, base of spines,	.62
Diameter across arm-bases,	.60

Locality.—Same as last.

CYATHOCRINUS. Miller, 1821.

(*Nat. Hist.* Crinoidea.)

Cyathocrinus rarus, *n. s.*

Pl. XXVII, Figs. i, i 1.

Only two specimens of this unique species have been observed; both crushed, and the parts thrown, more or less, out of their true relations to each other. The markings, or ornament of the plates, are very prominent, giving a rough appearance to the body. Our specimens show parts of three rays. The first ray-bearing pieces support, each, two free rays; these are again divided on the second piece ascending. This arrangement gives

twenty free rays on the second division of the arms. The ray-pieces, which form the base of the second division, each bear a short, blunt spine.

The pieces composing the body are too much disarranged to exhibit their true relations to each other. The basal pieces have a very prominent protuberance rising near the centre of each. One of the pieces forming the ring of the basals, is much larger than the others; this piece bears no prominent knob; its surface is nearly level. The raised bands, crossing the plates, consist of from two to three parallel ridges. All these pieces are covered with granules of irregular size.

The column is very large and strong for so small a body; it is composed of regular, round disks, placed in the column; alternately one large, and then smaller ones; the middle one of the three being larger than the two others; the largest size pieces are quite thick, compared with the thinner ones between them. The column has a uniform size for about three inches below the body, when it diminishes rapidly toward the lower extremity. In the smaller specimen figured, the column has nearly reached a point in four inches. The extremity of the column has been lost in both of the examples.

The smaller specimen appears to have been a free floating body, like *Woodocrinus macrodactylus*, and some species of *Glyptocrinus;* at least at some period during its growth.

Size of Specimen (*approximately*).

	INCHES.
Diameter of base,	.26
Height of base,	.15
Height of first radials,	.51
Diameter at top of first radials,	.55
Diameter of column near base,	.20

Locality and Geological Position.—Nucleocrinus bed, near mill, Falls of the Ohio, Clark County, Indiana.

Fragments are frequently met with; good examples are very rare.

N. Cyathocrinus, with which I am acquainted, is nearly related to this species. Plates and fragments of an undescribed, analogous species, is found at Buttonmould Knob, Jefferson County, Kentucky. They belong to a larger species, and are more delicately ornamented than our species.

The Buttonmould Knob locality is situated about one hundred feet above the top of the black slate, and has been referred to the subcarboniferous division of the rocks of Kentucky and Indiana, by those well qualified to give opinions upon this subject.

Cyathocrinus insperatus, *n. s.*

Pl. XXVII, Fig. k.

The body below the free rays is nearly as wide as high—obconical in form; above the free rays the proboscis is greatly expanded, being nearly as wide, and longer than the body below. The proboscis, or rather, sack, is composed of several rows of large pieces, one above another; hexagonal; longer than high. The ends of the pieces are equally truncated on both sides, forming a sharp angular point, by which the rows are joined; the pieces in adjacent rows alternating one above the other of those in the adjoining rows.

The plates of the calyx are very thin; basal pieces long; the first radials, subradials, and the two first anal pieces are nearly equal in size. The arms are long; very small; bifurcate on the summit of the second small first radial; giving off additional branches on the third piece above the branch below, three or four times. These branches also bifurcate. The precise arrangement of these branches is not clearly made out, owing to the condition of our specimen. The free rays do not appear to have been provided with pinula; they are round, composed of a single row of short pieces, nearly of equal size.

Size of Specimen.

	INCHES.
Diameter of body at base of free rays,	.25
Height to free rays,	.27
Height of sack above second anal piece,	.50
Diameter of sack,	.35 to .40
Length of free rays,	.45 to .50

Locality and Geological Position.—Crawfordsville, Montgomery County, Indiana. It occurs not abundantly in the silicious sandstones of the knob formation—*Safford's silicious* group—at the base of the subcarboniferous limestone. In some beds of these measures the fine mud has swept into the locality of the crinoidea, apparently burying them alive. These bodies are attached to the columns; all extended one way; the fingers unbroken, and the most delicate parts preserved in the now consolidated mud. The bodies have decayed, and left perfect moulds of the animals in the soft rock, to mark the place of their burial. In some of the beds water has carried lime, in solution, into these cavities; these are now filled with crystallized lime. Remarkable specimens of the empty moulds of crinoids are abundant.

Remarks.—Our specimens are attached to a block of stone, and somewhat distorted by crushing. The measurements are only approximately correct.

This species will be readily separated from *C. rotundus*, Hall, which it most nearly resembles, by the length and expansion of the proboscis, the greater length of the basal pieces, and the marked difference in the character of the pieces composing the arms. In

that species these pieces are about three times as long as their thickness; in our species their length is about equal to their diameter.

POTERIOCRINUS. Miller, 1821.

(*Nat. Hist.* Crinoidea.)

Poteriocrinus simplex, *n. s.*

Pl. XXVI, Fig. f.

Body conical, long and slim; basal pieces long and thin; subradials and two of the radials nearly of equal length; the pieces gradually increasing in width as they rise in the calyx. In our specimen the anal side is presented; it consists of about five pieces; the first is nearly as large as the first radials, and supports two long pieces a little smaller; all the pieces are slightly gibbous; sutures at the junction of the pieces strongly marked by the depression formed by the sides of the plates. The pieces are very thick; cavity of the body small; arms and summit unknown; column round, rapidly tapering from the body downward, formed of circular disks of equal thickness. The surface of our specimen is smooth, showing no markings.

Size of Specimen.

	INCHES.
Length of calyx to top of second radials, ...	.32
Diameter at summit of second radials, ...	.22
Diameter of base at top of column, ...	.15

Locality and Geological Position.—Nucleocrinus or lower crinoid bed, near mill, on the Falls of the Ohio.

This species is longer and thinner than any species observed; approaches *P. rhenanus*, F. A. Roemer, nearer than any other, and the form, the number, and arrangement of the pieces in the anal field.

Poteriocrinus cylindricus, *n. s.*

Pl. XXVII, Figs. l, l 1.

Body, from base to the free rays, cylindrical; abruptly rounded on the basal pieces; basal pieces short and thick, forming a low broad cup; radial pieces short; two of them, that are complete, reach the second radial; this is also quite short, and appears to bear a third radial, also short; it reaches to the base of the free rays; arms unknown. The dome, or proboscis, in our specimen, is crushed; its form is not known; the loose, disarranged

pieces indicate that it was covered by small spine-bearing plates. Column round; formed of disks of unequal size. Near the body they are arranged by two small and two larger pieces, and by a piece much larger than those above it. This arrangement is repeated seven or eight times in our specimen, with some irregularity in the size and thickness of the pieces. The column is quite large, when compared with the body it supports. Some of the pieces of the body are covered by very fine granules, placed quite close together.

Size of Specimen.

	INCHES.
Length of body to free rays,	.40
Diameter to summit of first radials,	.22
Length of remains of proboscis,	.55
Diameter of column, large pieces,	.15

Locality and Geological Position.—Nucleocrinus bed, Falls of the Ohio, near the mill. Fragments are not rare; good specimens very rare.

The flattened base gives this species the general appearance of Platycrinus. It terminates more abruptly at the column than any other Potinocrinus that has come under my observation.

PLATYCRINUS. Miller, 1821.

(*Nat. Hist.* Crinoidea.)

Platycrinus Leai, *n. s.**

Pl. XXVI, Fig. g, g 1.

Body, below the arm-bases, turbinate; smooth; slightly expanded at the junction with the column. The centre of the upper margin of the first radials expanded, forming on each, projections like the lip of a pitcher. Basal pieces three, of equal size; pentangular, forming a cup, equally divided at its upper margin into six slightly concave depressions, for the reception of the first radial pieces. First radials, six in number; subquadrangular; a little higher than wide; a slight, but distinctly defined, smooth ridge, occupies the centre of the first radials, extending from the basals to the lip-like projection, on which are placed the second radials. The ridges upon three of the first radial pieces continue downward along sutures, at which the vertical sides of the basals are united to the swollen part of the basal pieces, with which they unite and are lost in it. The second

* This species is dedicated to that able and earnest servant of the Natural Sciences, Isaac Lea, LL.D., of Philadelphia, Pennsylvania.

radials are very small; four times as broad as high. The third radials are larger than the second; flat; cuneiform; very low, or short on their vertical margin; each of these support the first piece, or the base of the free rays. The free rays rise singly, one on each radial series; they are composed of rather large, thin, semicircular pieces, which abut squarely against each other at the centre of the back of the rays; the pieces of the ray do not interlock with each other, so far as they are preserved on the examples observed. No part of the dome is attached to any specimen seen; its form and arrangement is unknown. All the plates of the body are very thin, except near the attachment to the column and the arms.

Column round, composed of circular pieces; the smaller ones are about three times as thick as the larger pieces. The pieces are alternately disposed, thicker and thin ones. The thin pieces are enormously expanded; some have been observed surrounding a small one—two-twentieths of an inch in diameter—that were nearly an inch in diameter, of a thickness not greatly exceeding one hundred to the inch, the enlarged pieces still retaining their perfectly circular outline. These rounded, disk pieces, surrounding a small columnar piece, was for many years a mystery; their connection could not be traced to any known crinoidal body until the discovery of the specimen figured, Plate II, Fig. g 1, showed their connection with Platycrinus Leai, of this paper.

Size of Specimen.

	INCHES.
Height of basal cup,	.27
Height to summit of first radials,	.70
Diameter at summit of first radials,	.97
Diameter of columnar facet,	.20
Height of second and third radial pieces,	.12
Width of third radial pieces,	.22

Locality and Geological Position.—Upper crinoideal limestone, Bear Grass Quarries, Jefferson County, Kentucky. Fragments abundant; good specimens very rare. The epidermis, or muscular covering, which no doubt in life covered all crinoideans, and upon which the ornamentation found on so great a number of these bodies, in such exquisite beauty and variety, is placed, does not appear to have been preserved on any fragment of the specimens recovered. Under a strong lens, obscure striæ are observed on some parts of some of the larger plates.

The rocks of this locality, which are of great thickness in New York, in the geological horizon immediately above the Niagara group, are here quite thin; and there is a mingling in these beds of the fossils of the Niagara, Upper and Lower Hilderburgh, &c., to the base of the black slate.* The entire thickness of these beds, at localities where the

* *Genesee slate.* See Vol. II, Illinois Reports, Introduction, p. 8.

hydraulic limestone is thinnest, being about twenty feet. Several specimens, *Halsytes escaroides*, have been obtained within eight feet of the base of the slate.

NOTE.—It is with some hesitation that P. Leai is referred to Platycrinus. Our description will show that it possesses characteristics that ought to exclude it from Platycrinus. It also differs from *Hexacrinus, Austin,* and probably possesses characters of at least sub-generic value, by which it may be separated from other Platocrinoid forms.

NOTE.—Since the above description was written, Dr. Knapp, of Louisville, Kentucky, has kindly furnished me with several examples of *P. Leai.* They vary in size; some of them are shorter, others longer than those figured. One of the specimens retains the epidermis upon two of the large radials, and one of the basal pieces. The surface-markings on these consist of a finely granulose surface, invisible to the unaided eye; upon this granulose surface are lines of larger granules, about one-twentieth of an inch apart. The lines are not regular; they appear to start at the base of the large radials; converging, meet at the centre of the radials; those starting from the corners of the pieces meeting at the arm-bases; those above, on either side, parallel to the longest line below them.

GENUS DOLATOCRINUS. LYON, 1857.

KY. GEOL. REPORTS, VOL. III.

DOLATOCRINUS MARSHI, *n. s.*

Pl. XXVII, Figs. n, n 1, n 2.

Body, below the arms, discoid, with five broad, sharp carina, which rise perpendicularly from the margin of the basal pit, and extend outward, equally elevated to the centre of the third radials, the carina rising gradually from the margins of the radials, then more rapidly to the centre of the pieces. At the centre of the third radials the carina sends out branches, not quite so bold as the main stem, but strong, involving all the pieces of the superradials up to the arm-bases. Arm-bases prominent, in groups of two to each ray, producing a lobed, pentagonal figure of that section of the body. The dome is sub-conical; twice as high as the body below the arms; surmounted by a thick, strong, sub-central proboscis. The interradial fields unite to the dome-covering between the arms. Basal pieces long; bending squarely (at right angles) into the basal pit; six-sided; the upper part (not concealed in the pit) horizontally disposed. Second radial pieces sub-quadrangular; differing slightly in size. Third radial pieces pentangular; varying in form and size. The first, second, and third radial pieces of the several rays, differ very little in length, in the same ray—the rays are of variable length. The third radials each support two superradials, nearly as large as the ray-pieces below them. These support, some one, others two superradial pieces beneath the arm-bases. Basal pit: this is filled by the "*atlas*" of a column, such as that described in this paper. Its depth is not seen. Two

less perfect specimens than that figured, exhibit the basal pit close and less deep than *D. lacus* and several others; the sides rising nearly perpendicularly with the base of the body. The "*atlas*" is seen in the figure (n, Pl. XXVII), surrounded by the false basals, which form the outer ring within the basal pit. The basals, as is usual in examples of this genus, are hidden by the first radials.

Interradial fields.—These are five in number. The pieces composing the several fields vary in number, from seven to nine to each field. The first is large, subovoid; nine-sided; a little larger than any other pieces of the calyx. Upon the upper margin of these rest another large piece, equal in size to the radial pieces; they differ in form, but are all six-sided. Upon the upper margins of these rest three interradials of the third series, except in one field, where there are only two of these pieces, the third side supporting one of the superradials. The fourth series consists of two to each field, except one, which has four pieces in the fourth range of the interradial field. The fourth range supports two pieces to each field; the upper end of these are joined to the points of the long pieces which lie between the lobes on the dome.

Interbrachials.—From two to four to a field, and are wedged between the arm-bases; when of four pieces, they are in pairs, one above the other. The dome is covered by large pieces; each field between the lobes contain a pair of the largest, which reach from the arm-bases toward the proboscis; they are six or seven-sided; long; broadest at the upper extremity; pointed, or very slightly truncated at the lower end; joining each other by their longest sides, at the centre of the depression between the lobes. A circle of large pieces surround the dome; all of these rest partly upon the ten long pieces. The pieces composing this zone are of different sizes; they also differ in form; all six-sided; two of the largest pieces of the circle rest directly over two of the long pieces; three other groups of the long pieces unite under the suture, uniting two of the pieces forming the circle, so that the sutures uniting both sets of pieces, form one line from the arm-bases to the base of the second circle surrounding the dome near the base of the proboscis. The specimen figured has the proboscis broken off through the pieces of the second zone which surround it. Below the zone described, and between the groups of long pieces, are groups of from five to seven pieces, the upper one of which is joined to the circle above the group of long pieces, and on which it rests. The lowest piece of these groups is lanceolate; is lodged between the arm-bases, and unites with the interbrachials. The upper and largest piece of these several groups is of the same size and form as the pieces comprising the first zone around the top of the dome. Around the arm-bases, the pieces are numerous and quite small. The pieces comprising the lower zone, and the large ones of the groups above the arms, are surmounted by a group of from three to five rough, pointed spines, confluent near their bases. The fragments of the second zone, remaining at the base of

the proboscis, are ornamented by three or more hemispherical tubercles, differing in size, irregularly disposed across the pieces. All the other pieces of the dome are gibbous or concave, and not ornamented. In better preserved specimens, it is probable that the whole surface of the dome will be found covered with fine granules.

All the pieces of the body below the arms are covered with fine ridges, disposed in groups, radiating from the centre of the pieces; on the radials, and larger pieces, these number from six to ten in each group; thus the margins of the first interradials are ornamented by about seventy of these ridges. Column and arms unknown.

Size of Specimen.

	INCHES.
Height of body below the arm-bases,	.36
Height of dome to base of proboscis,	.67
Height of whole body,	1.03
Diameter of calyx at arm-bases,	1.37
Diameter of base of proboscis,	.46
Diameter of basal pit,	.30

Locality and Geological Position.—Nucleocrinus bed, or lower crinoid bed, Falls of the Ohio, Clark County, Indiana. Very rare. The specimen figured is of an adult, unusually large for this species.

A few years ago a crinoidal body was received in exchange, from a friend, having a label attached, "Collected near Dayton, Ohio."

This fossil attracted considerable attention; its anomalous structure, and general appearance, separated it from all crinoids that had come under my observation.

In the year 1860 a drawing was made of it, preparatory to description. The troubled condition of the country at the time, and during the war, delayed the paper describing it. I now propose a description of it, and to erect a new genus for its reception, and other similar forms, under the name of Ataxiacrinus (*Ataξία*), irregular; and the following generic formula is submitted.

Ataxiacrinus, *n. g.*

Generic Formula.

Basal pieces, 5.
Radial pieces of the first series in three rays, 1 to each ray to the free arms.
Radial pieces of the first series in two rays, 2 to the free rays.
Supplementary radials to the rays with two radials, 1.
All the free rays, and supplementary radials, arm-bearing.
Dome covered by many small pieces.
Anal pieces. (?)
Column subpentagonal; opening pentelobate.
Arms unknown.

ATAXIACRINUS CAPONIFORMIS, *n. s.*

Pl. XXVII, Figs. o, o 1, o 2, o 3.

Body flat; discoid below the arms; nearly flat on the dome.* Basal pieces five; five-sided, and united they form a pentagonal piece, the sides of which are nearly equal; the pentelobate opening into the column from the body notching the base of the pieces of the base. The radial piece on the left of Fig. o 2, Plate XXVII, and on the right of Figs. o and o 1, is much the largest piece in the body; is seven-sided, and about half its length is curved over upon the dome, nearly three times as wide as the distance from the ends of the basals to the base of the free rays, which rest upon it. On both vertical sides of the largest piece is placed one subquadrangular piece, the first of the two irregular rays; upon these rest the second radial pieces; that upon the ray (Fig. o, Plate XXVII), is much larger than that upon the opposite irregular ray; it is hexagonal in form, and much like the largest piece, and the largest first radials of the other rays. Both of the second radials in the irregular rays, support, each, one supplementary radial, and the base of one of the free rays. The supplementary radials are placed one upon the left side of the ray (Fig. o, Plate XXVII), and is a larger piece than that upon the left side of the opposite ray. The other two first radials, those on the right (Fig. o 2, Plate XXVII) and the left (Fig. o 1) are nearly of the same size, of similar form to the largest radial; like that they curve over the upper surface of the dome. All of the upper radials, except one which carries (on our specimen) a small subquadrangular piece of one of the free rays, show openings into the body. This one is crushed upon, and probably conceals it. Both of the supplementary radials carry a small fragment (supposed to be) of ray pieces. They appear to be solid (?), and not open as in the regular ray pieces. The pieces covering the dome are small and slightly gibbous, and arranged without any apparent order. No oral opening can be perceived.

The form of the arms, and their arangement, is unknown.

The column is composed of rather thick disks, placed one upon the other, with a thin, muscular disk between them; they are all pentelobate. A groove lies between the rounded corners of the pieces, which form the column. The thick pieces of the column between the grooves have a depression in their edges, about half the length of the space between the grooves.

* The specimen is slightly crushed, bending toward each other the irregular rays; producing, by the crushing, several wrinkles on the dome-cover, and pushing it upward. The remains of the free rays on the irregular rays project upward, producing a figure not unlike a dressed capon. The species is described as if our specimen had not been distorted.

Columnar opening in all parts of the column is of the same form in all its sections, when broken, as that penetrating the body through the basal pieces.

The surface of the calyx, below the free rays, irregularly granulose.

Size of Specimen.

	INCHES.
Greatest diameter,	1.36
Vertical height to free rays on the largest piece,	.44
Vertical height to the free arms on longest ray,	.77
Diameter of columnar facet,	.30
Greatest diameter of basal pieces united,	.78

This species will be readily distinguished from all known crinoidea.

Genus Zeacrinus.* *Troost.*

Synon. Cupressocrinus (sp.), McCoy, 1849. Ann. Mag. Nat. Hist., 2d Ser., Vol. II, p. 224. Not Gold., 1832.

Poteriocrinus (sp.), de Koninck and Lehon, 1854. Recherch. Crinoides, p. 91, and of some others.

Hydreiocrinus (sp.), de Koninck, 1858. Bull. Acad. Royale Belgique, 2d Ser., t. iii, p. 19.

Zeacrinus (Troost), Hall, 1858. Iowa Report, Vol. I, Part 2d, p. 541.

Zeacrinus Stimpsoni, *n. s.*

Pl. XXVII, Figs. m, m 1.

Body sub-cylindrical; slightly constricted at the summit of the subradial plates; composed of plates covered closely with fine granules; centre of subradial plates gibbous; base small; hidden by the column; depression at the base broad, extending to the centre of the subradials, which are nearly of equal size, that under the anal field being the largest; it is six-sided; the five other pieces of the subradials are five-sided; about three times as long as wide; sharply curved at the margin of the basal pit. First radials nearly as long as wide; squarely truncated for the reception of the second radials; angular below; deeply interlocked between the subradials; the lower part prominent as high as the upper extremity of the subradials; deeply depressed midway between the summits of the subradials and the base of the second radials; at their junction with the second radials enlarged, forming a lip or ridge along the suture between them and the second radial pieces. Second radials, five; lanceolate; about as wide as high; five-sided; vertical sides very short, full or ridged along the centre of the pieces; margins prominent; deeply depressed toward the

* The synonymy of the genus above is extracted from Reports of Geological Survey of Illinois, Vol. II, p. 185.

vertical sides from the central ridge. Each second radial bears two pieces of the free rays. The rays again divide on the sixth piece above the second radials. The pieces forming the rays are very rough, having a raised angular rib along the back of each, the direction of which is alternately to the left and right, on the pieces forming the rays one above the other. Each ray-piece bears two prism-shaped pinulæ, not quite opposite to each other, but alternately one a little above the other, one of the angular corners of the prism forming the back of the pinulæ. The junction of the rays with the pinulæ is marked by a prominent, triangular protuberance upon the ray-pieces immediately above the junction of the pinulæ with it. There are about twenty-six ossiculæ in each ray, and any one of its branches. All the rays are equal. The ridges on the ray-pieces, with the angular pinulæ, and the zigzag arrangement of the ray-pieces, gives a very rough appearance to the body above the calyx.

Anal pieces: three are made out distinctly; the largest rests against the right side of the subradial; it is five-sided, angular at the summit, resting between two subradial pieces, and supports one large and one smaller anal piece of the second series, the smallest of which rests on the summit of the left subradial.

Proboscis: since the drawing was made (Plate XXVII, m and m 1) I have removed part of one of the branches of the ray (Fig. m), and uncovered between the main branches of the ray down to the anal pieces, thus exposing to view a proboscis reaching nearly to the top of the Fig. m. It is composed of a series of rather large pieces, in two adjacent rows, interlocking with each other by angular points at the ends of the pieces. The pieces are marked by prominent ridges, most strongly developed at their margins; composed of about five rows of pieces.

Column round, covering the basal pieces, which are unknown.

Size of Specimen.

	INCHES.
Length of specimen,	1.32
Height of calyx,	.34
Diameter of calyx (approximately),	.42
Length of free rays to first bifurcation,	.42

Locality and Position.—Found in sandy mud-stones, near the upper part of Safford's sillicious group of the subcarboniferous rocks. It is rather rare. Our specimen is crushed.

PLATE I.

f. POTERIOCRINUS SIMPLEX. N. S.

g—*g* 1. PLATYCRINUS LEAI. N. S.

a. HADROCRINUS DISCUS. N. S.

b. HADROCRINUS PLENISSIMUS. N. S.

b. 1. HADROCRINUS PLENISSIMUS. Base seen from the inside of the animal, twice the diameter of the base of *a.*

b. 2. HADROCRINUS PLENISSIMUS. Arm bases. Fragment of an individual four and a half inches in diameter.

b. 3. HADROCRIMUS PLENISSIMUS. Fragment of a specimen three inches in diameter, showing seven (7) ranges of plates below the arms.

c. HADROCRINUS ANGULARIS. N. S.

d. 1. ACTINOCRINUS PENTASPINA. N. S. Profile.

d. ACTINOCRINUS PENTASPINA. N. S. Basal view.

e. ACTINOCRINUS MULTACORNU. N. S.

h. Column of "*Dolatocrinus.*"

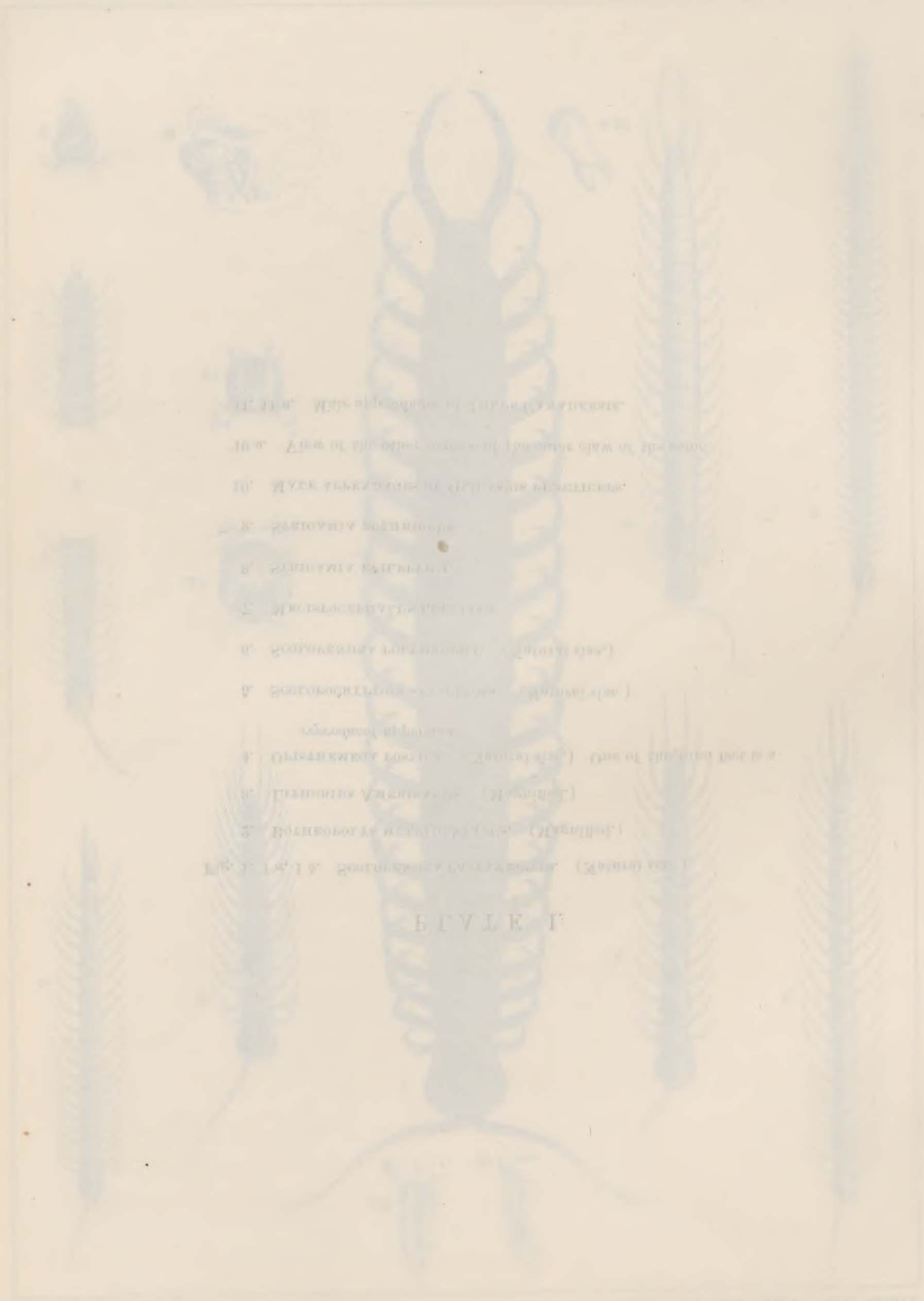


PLATE I.

Fig. 1. 1 *a*, 1 *b*. SCOLOPENDRA CASTANEICEPS. (Natural size.)

2. BOTHROPOLYS MULTIDENTATUS. (Magnified.)

3. LITHOBIUS AMERICANUS. (Magnified.)

4. OPISTHEMEGA POSTICA. (Natural size.) One of the hind feet is a *reproduced* appendage.

5. SCOLOPOCRYPTOPS SEXSPINOSA. (Natural size.)

6. SCOLOPENDRA POLYMORPHA. (Natural size.)

7. MECISTOCEPHALUS LINEATUS.

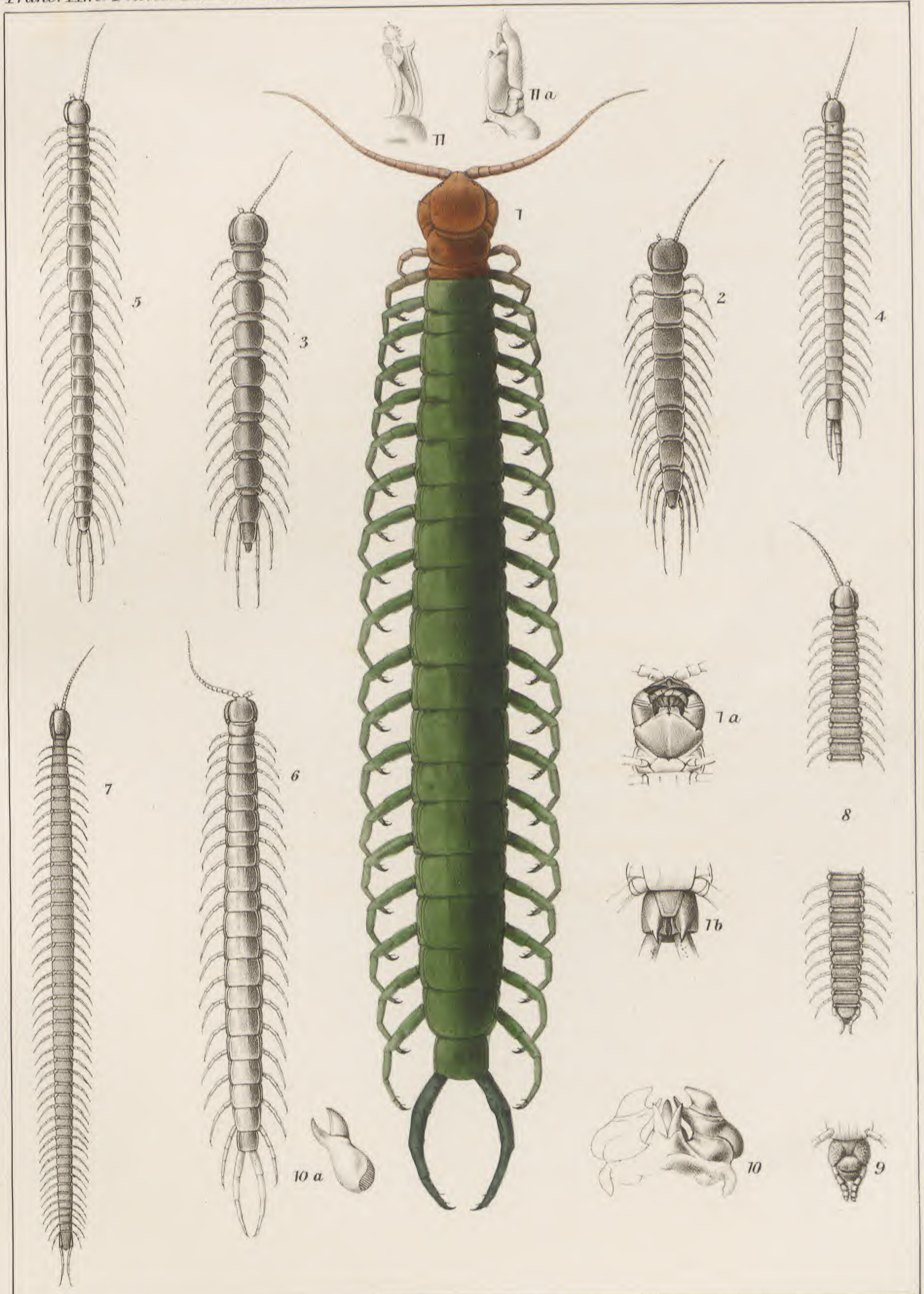
8. STRIGAMIA EPILEPTICA.

9. STRIGAMIA BOTHRIOPUS.

10. MALE APPENDAGES OF OLIGASPIS PUNCTICEPS.

10 *a*. View of the other surface of the outer claw of the same.

11, 11 *a*. Male appendages of IULUS CANADENSIS.



Drawn by A.J. Ibbotson.

Bowen & Co. lith & col. Philada.



PLATE II.

Fig. 1.* IULUS IMMACULATUS.

2. IULUS PENNSYLVANICUS. This figure is scarcely hairy enough, and not sufficiently acutely mucronate.

3. IULUS VENUSTUS.

3 *a*. Head of the Male of same.

3 *b*. Head of the Female.

4. IULUS CANADENSIS.

5. IULUS CANALICULATUS.

6. BRACHYCYBE LE CONTII.

7. POLYDESMUS CANADENSIS.

8. POLYDESMUS GRANULATUS.

9. POLYDESMUS SERRATUS.

10. POLYDESMUS SETIGER.

11, 11 *a*. SPIROSTREPHON LACTARIUS.

12. IULUS PILOSISCUTA. (This figure is not good, the hairs instead of being merely indicated should be prominent.)

13. IULUS VIRGATUS.

14. SPIROSTREPHON CÆSIOANNULATUS.

15, 16. IULUS LAQUEATUS. (Fig. 15 is the better.)

17, 17 *a*. OLIGASPIS PUNCTICEPS. (Natural size.)

* All the figures on this plate are magnified


3a


3b


2


3


5

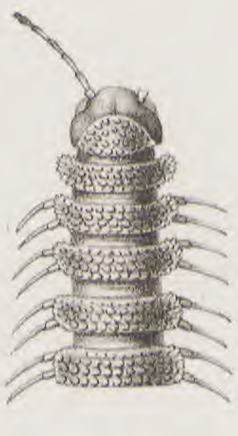

1

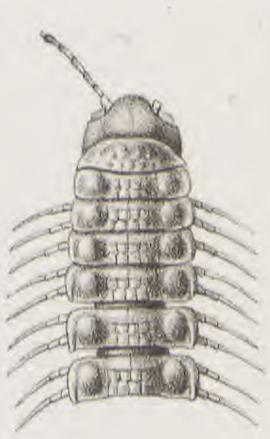

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10


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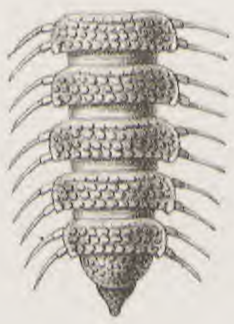

6


8


7












12


11a


15


17


17 a


13


11


6 a


14


16

Drawn by A.J Ibbotson

Bowen & Co. lith. Philada.

PLATE III.

Fig. 1. CERMATIA FORCEPS. (Natural size.)

1 *a*. Magnified view of head of same.

2. SPIROBOLUS MARGINATUS. (Natural size.)

2 *a*. Head of the same. (Magnified.)

2 *b*. Tail of the same. (Magnified.)

3. This figure is a failure; it does not even resemble what it was drawn from

4. POLYDESMUS ERYTHROPYGUS. (Natural size.)

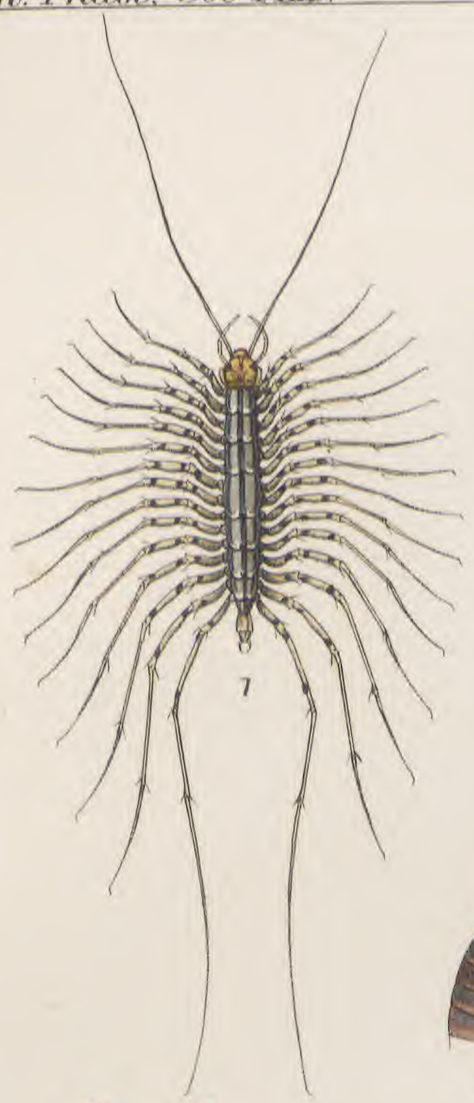
5. POLYDESMUS FLORIDUS. (Natural size.)

6. POLYDESMUS CORRUGATUS. (Natural size.)

6 *a*. Magnified view of under side of posterior portion of same.

7. POLYDESMUS TRIMACULATUS. (Natural size.)

8. POLYDESMUS VIRGINIENSIS. (Natural size.)



1



2



3



2a



2b



4



1a



6a



5



6



7



8

Drawn by A.J. Ibbotson.

Bowen & Co. lith. & col. Philada.

SECTION

OF

LAKE RIVER AND CANAL NAVIGATION

FROM

LAKE SUPERIOR TO THE GULF OF THE St LAWRENCE

Horizontal Scale Sixty miles to one inch.
Vertical Scale, Four hundred feet to one inch.



ENGRAVED FOR THE LAKE & RIVER NAV. CO.

Meteorological Observations at Montreal

T. E. Blackwell.

shewing the daily Range of temperature the proportion of Cloud and the quantity of Rain with the direction of the Rain bearing Winds, during the years 1858, 1859, 1860, 1861.

Trans. Amer. Philosoph. Soc. Vol. XIII. Pl. V.

MAP

INTENDED TO ILLUSTRATE

FIVE

TOPOGRAPHICAL TYPES

OF EARTH SURFACE

between

CINCINNATI AND THE SEA

by J. P. LESLEY.

1866.

CINCINNATI
PORTSMOUTH
CHARLESTON
WINCHESTER
STAUNTON
GORDONSVILLE
RICHMOND
SOMERSET
WYTHEVILLE
Greenbrier R.
Kanawha R.
Clinch R.
Holston R.
French broad R.
KNOXVILLE
Tennessee R.
SALISBURY
RALEIGH
FLORENCE
ABBEVILLE
APPALACHIAN MOUNTAINS
PIEDMONT
ATLANTIC SLOPE



Les Lesquereux, del.

T. Sinclair's lith, Phil.ª



PLATE VIII.

Fig. 1. Asterophyllites stachyoides. *Wood.* 1 *a.* Same, magnified, showing nutlet.

" 2. Annularia minuta. *Br.*

" 3. Sphenophyllum latifolium. *Wood.*

" 4. Lepidodendron dubium. *Wood.* 4 *a.* Magnified leaf scar.

" 5. Sigillaria solana. *Wood.*

" 6. Lepidodendron salebrosum. *Wood.*

" 7. Sigillaria perplexa. *Wood.*

" 8. 8 *a.* 8 *b.* 8 *c.* 8 *d.* Odontopteris lescurii. *Wood.*

" 9. Odontopteris rotundifolia. *Wood.*

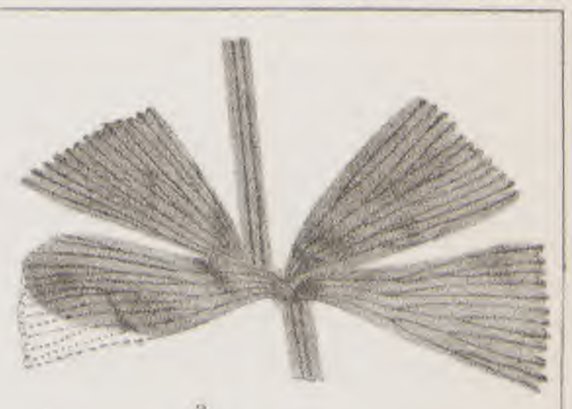
" 10. Sphenopteris pterota. *Wood.*



1 1a



2



3



4



4a



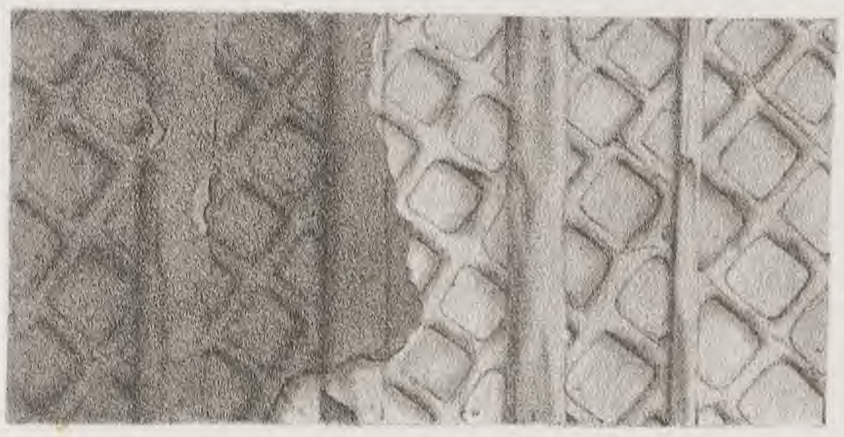
5



6



8



7



8b



8c



8a



10



8d 9

Drawn by E. J. Nolan.

Bowen & Co. lith. Phila.da.

PLATE IX.

Fig. 1. LEPIDODENDRON VENUSTUM. *Wood.* 1 *a.* Magnified view of a portion of the surface of the same.

" 2. LEPIDODENDRON ICTHYOLEPIS. *Wood.*

" 3. SIGILLARIA CAMPTOTÆNIA. *Wood.*

" 4. LEPIDODENDRON CHEILALÆUM. *Wood.* 4 *a.* Magnified leaf scar of same.

" 5. LEPIDODENDRON URÆUM. *Wood.*

" 6. LEPIDODENDRON DICROCHEILUM. *Wood.* 6 *a.* Magnified leaf scar of same.

" 7. SIGILLARIA CYMATOIDES. *Wood.* 7 *a.* Magnified view of leaf scar. (These figures have not sufficiently prominent the elevation of lower part of leaf scar.)

" 8. LEPIDODENDRON DREPANASPIS. *Wood.*

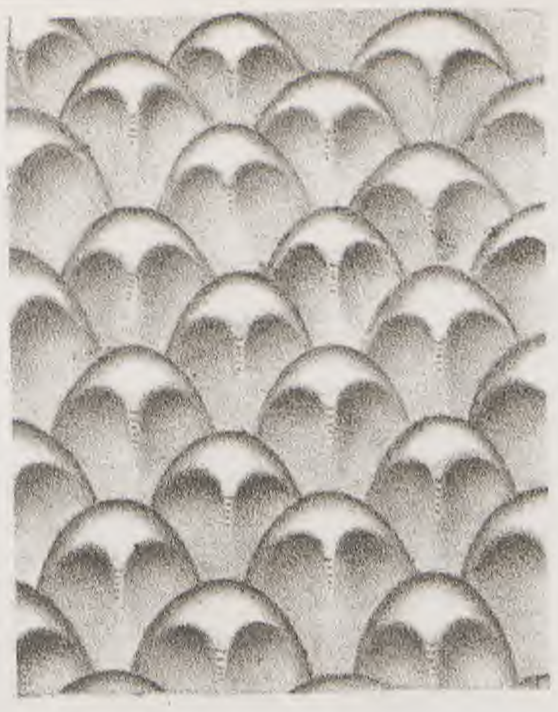
" 9. SIGILLARIA BISTRIATA. *Wood.*



1



1 *a*



2



3



4



4 *a*



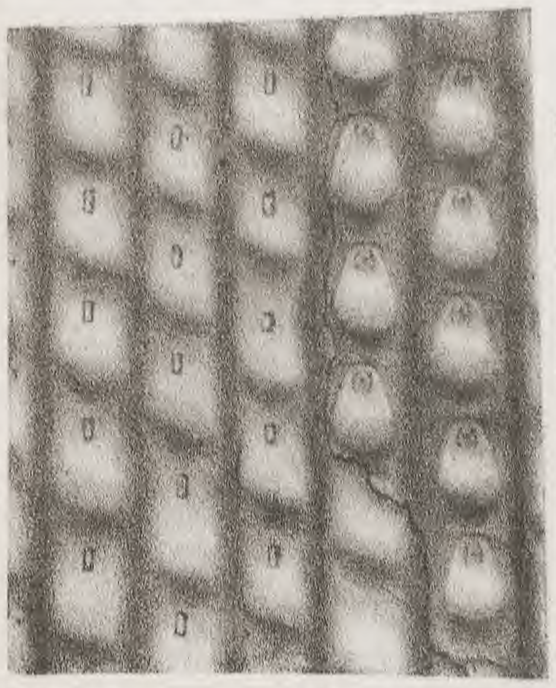
5



6 *a*



6



7



7 *a*



8



9

Drawn by E. J. Nolan

Bowen & Co. lith. Philada.



PLATE X.

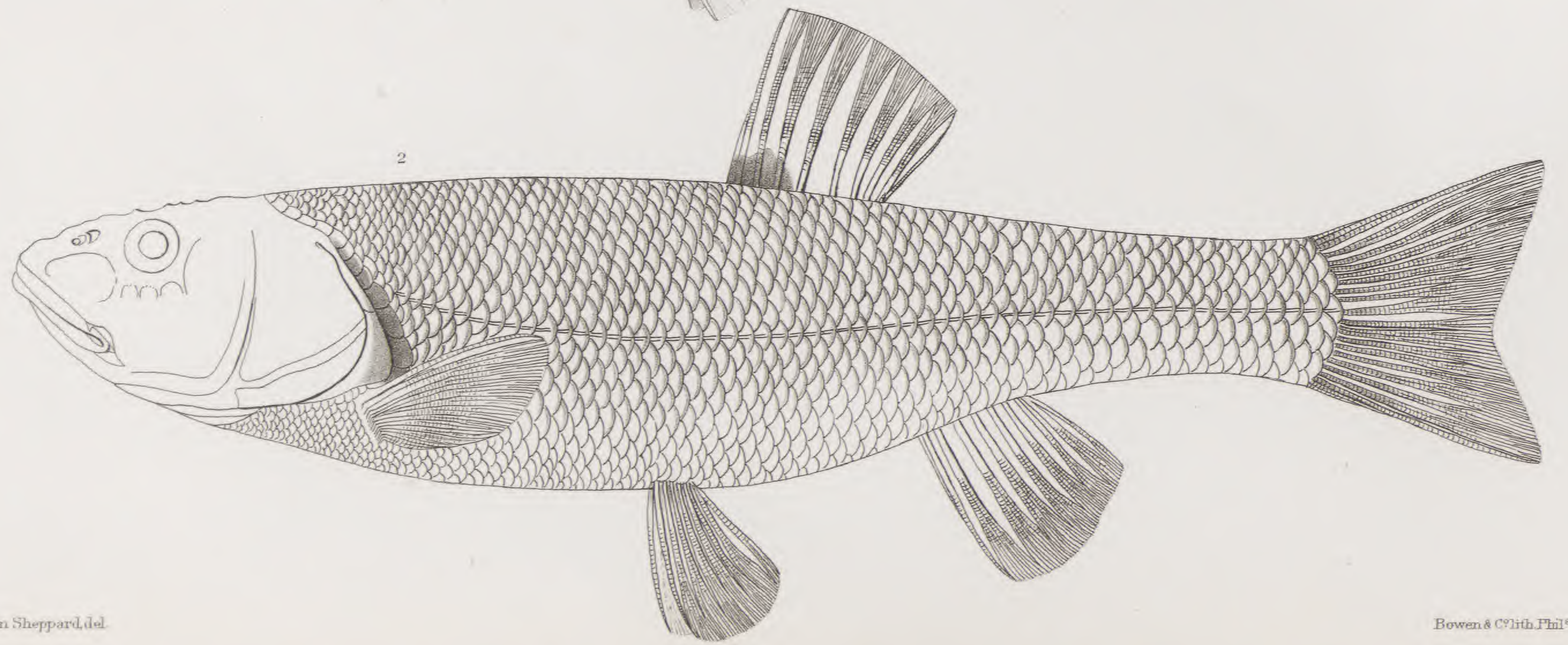
Fig. 1. SEMOTILUS RHOTHEUS. *Cope.*

" 2. SEMOTILUS CORPORALIS. *Mitch.*

1



2



Edwin Sheppard, del.

Bowen & C°lith. Phil.ª

PLATE XI.

Fig. 1. EXOGLOSSUM MAXILLINGUA. *Les.*

" 2. HYBOPSIS PROCNE. *Cope.*

" 3. HYPSILEPIS KENTUKIENSIS. *Raf.*

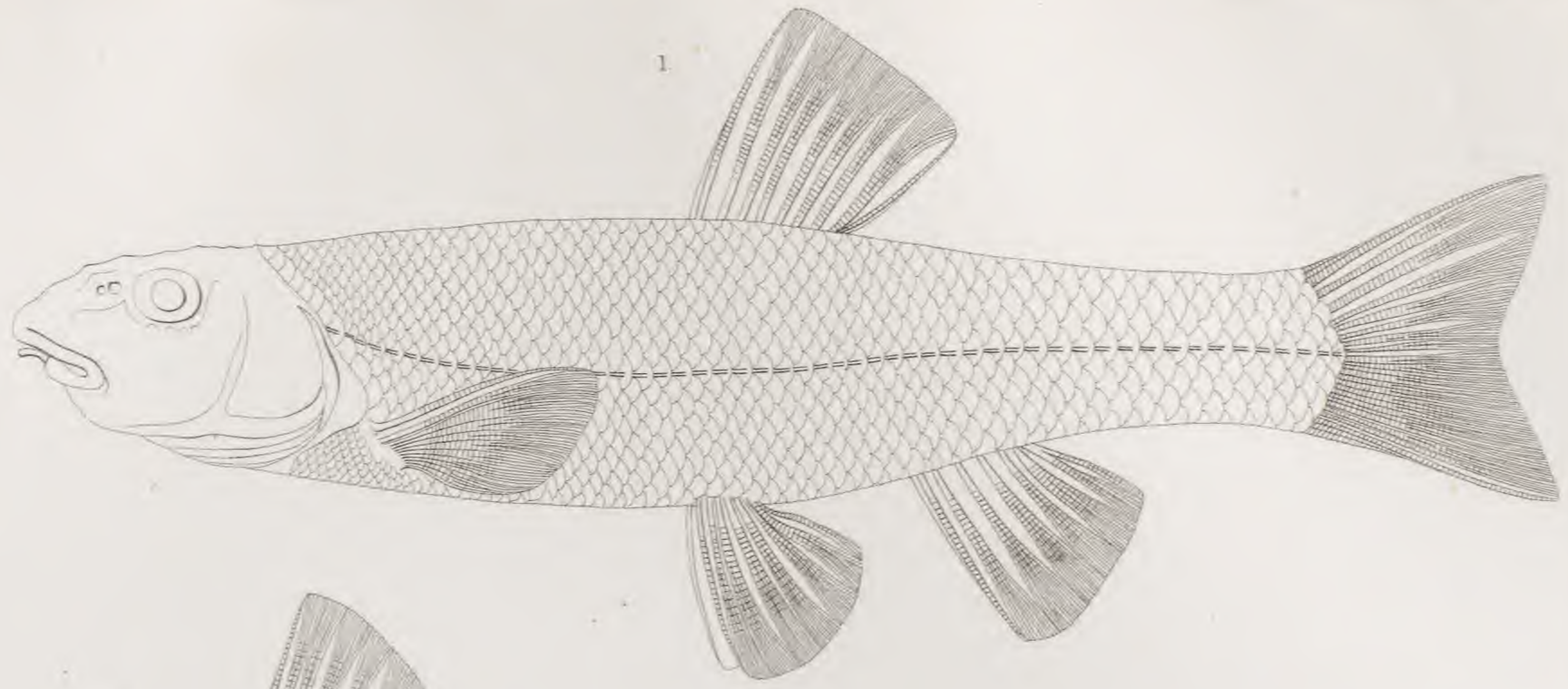
" 4. CERATICHTHYS PROSTHEMIUS. *Cope.*

" 5. CERATICHTHYS BIGUTTATUS. *Kirtl*

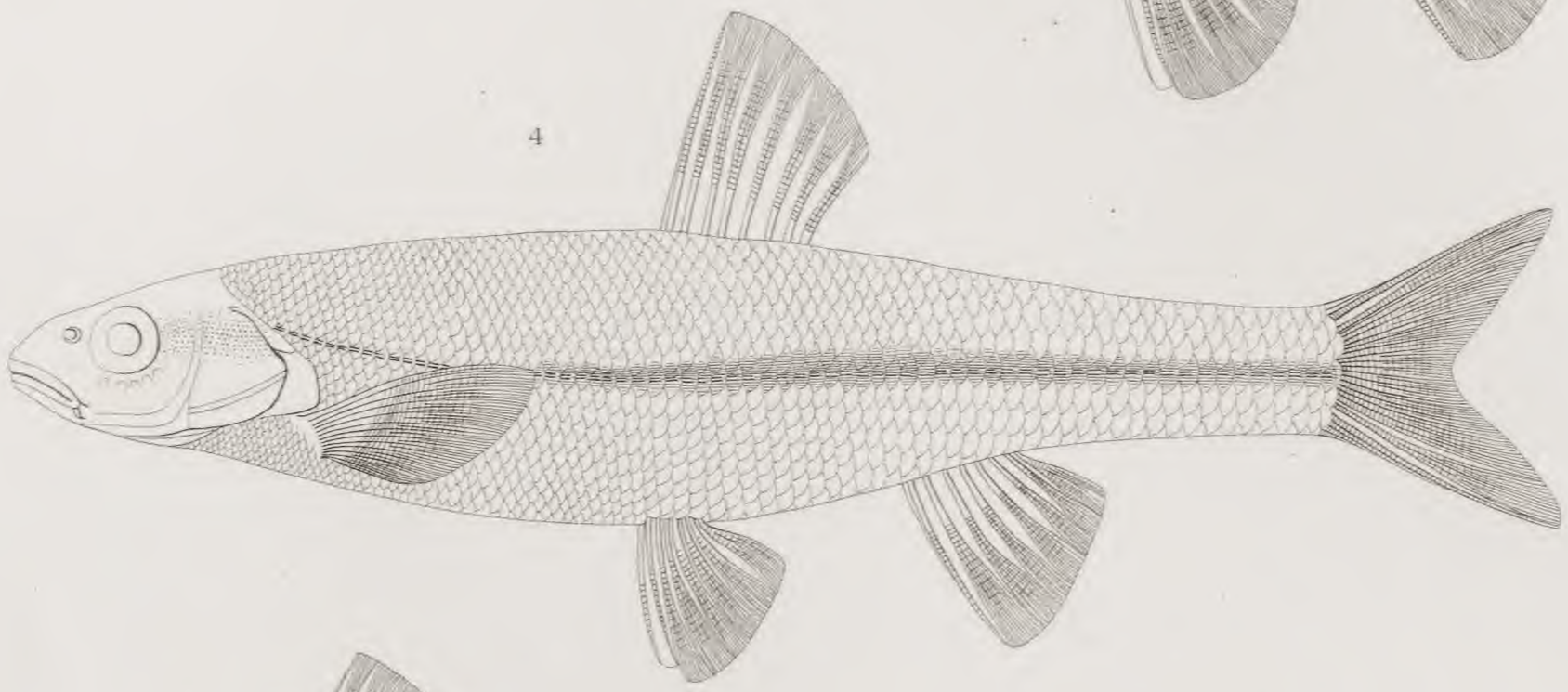
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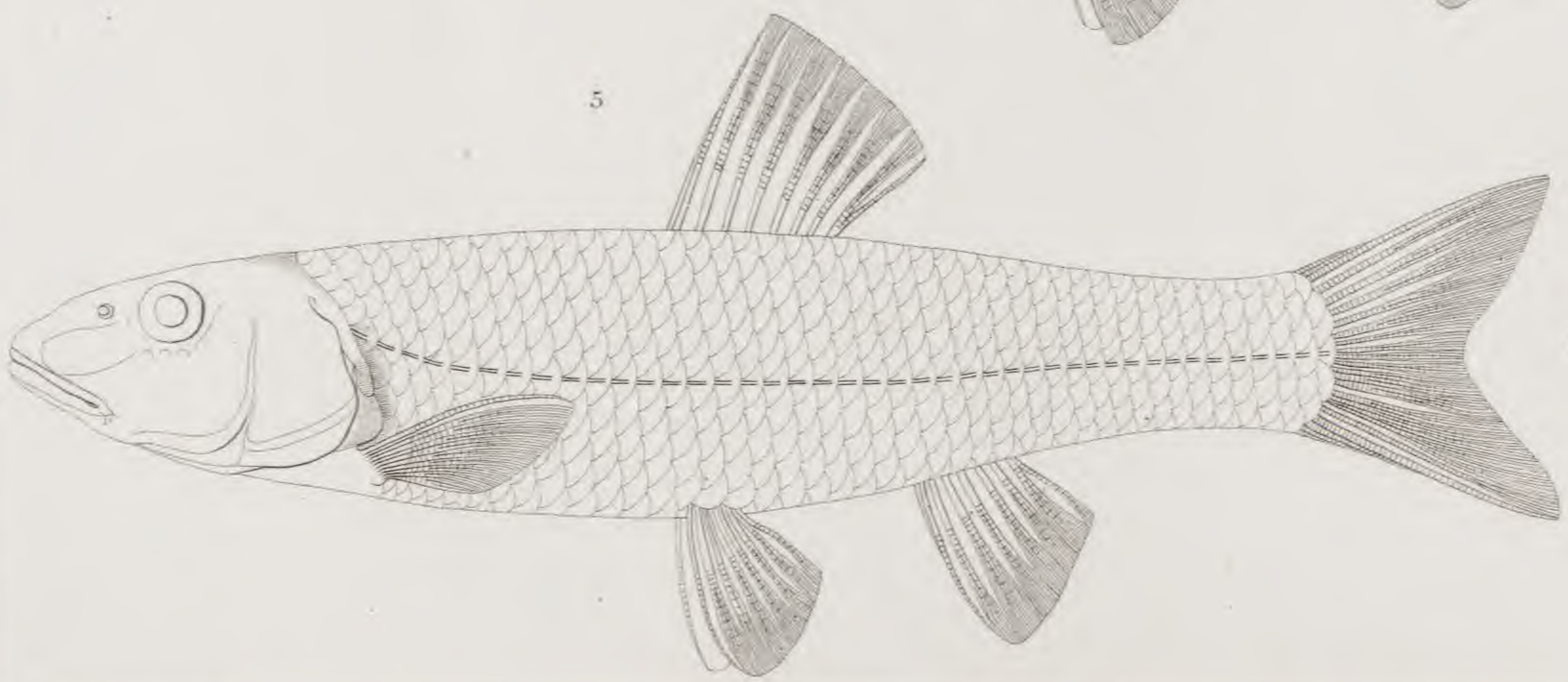
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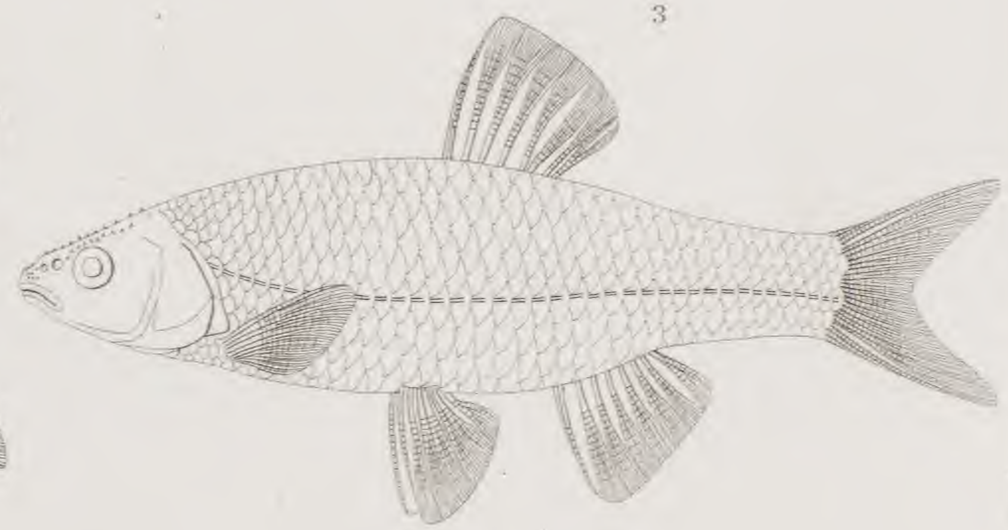
4



5



3



Edwin Sheppard del.

Bowen & C°lith Phil.ª



PLATE XII.

Fig. 1. Ceratichthys dissimilis. *Kirtl.*

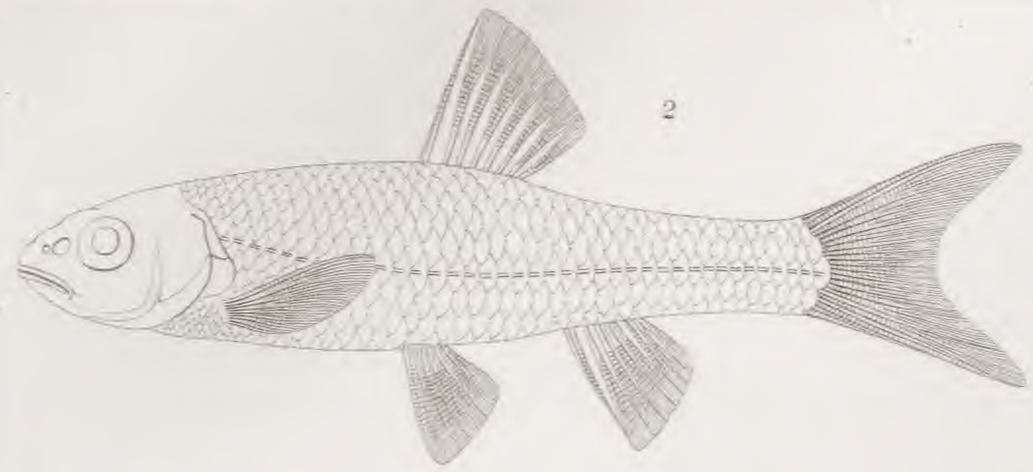
" 2. Ceratichthys micropogon. *Cope.*

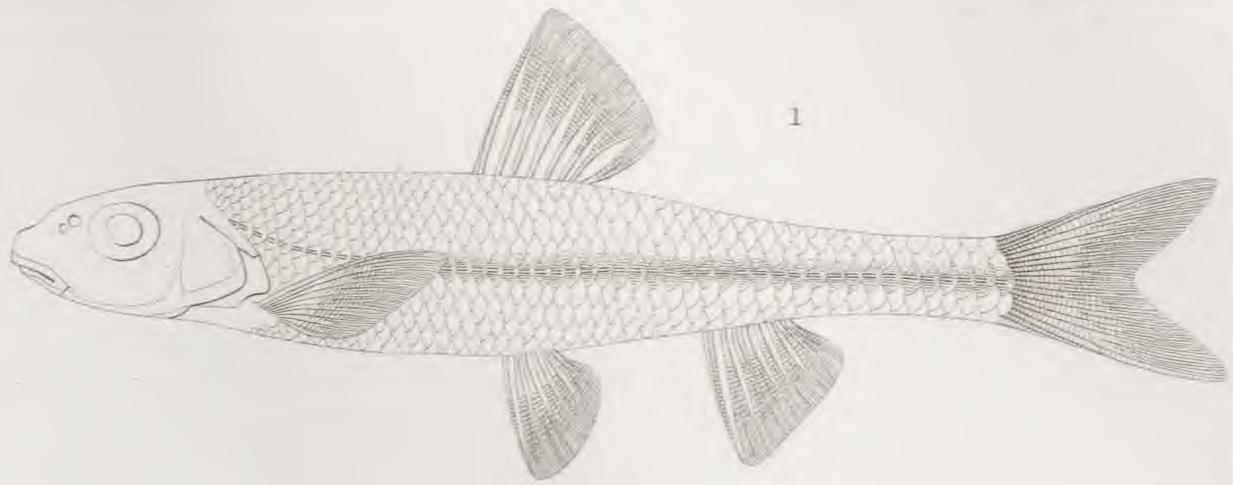
" 3. Hybopsis hudsonius. *Clinton.*

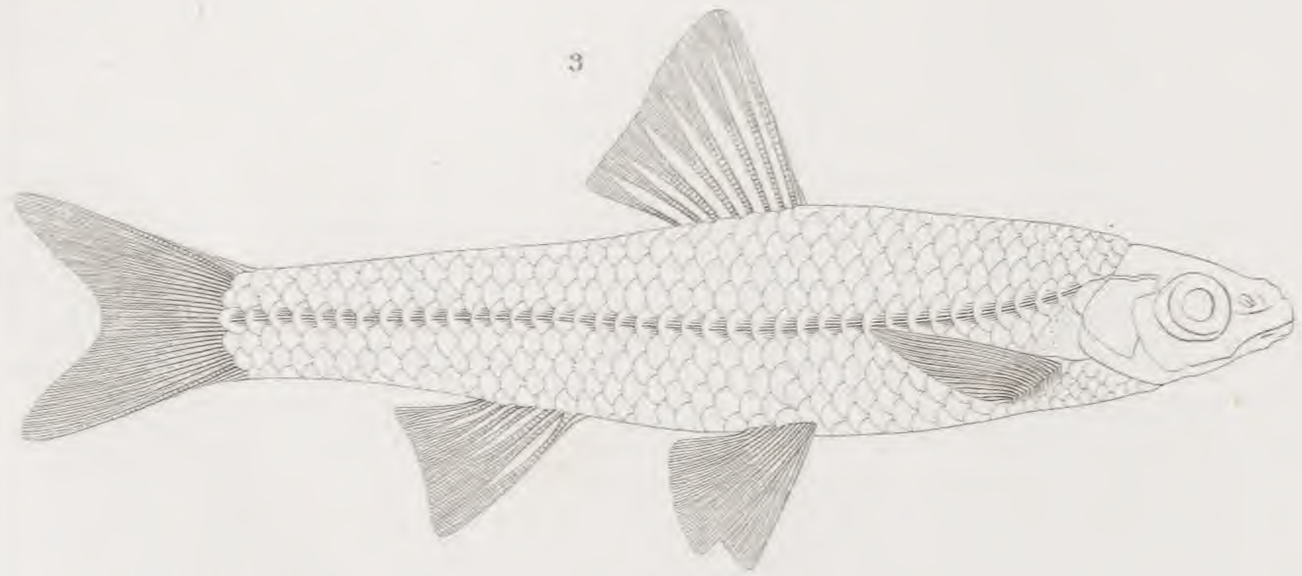
" 4. Hybopsis hæmaturus. *Cope.*

" 5. Argyreus nasutus. *Ayres.*

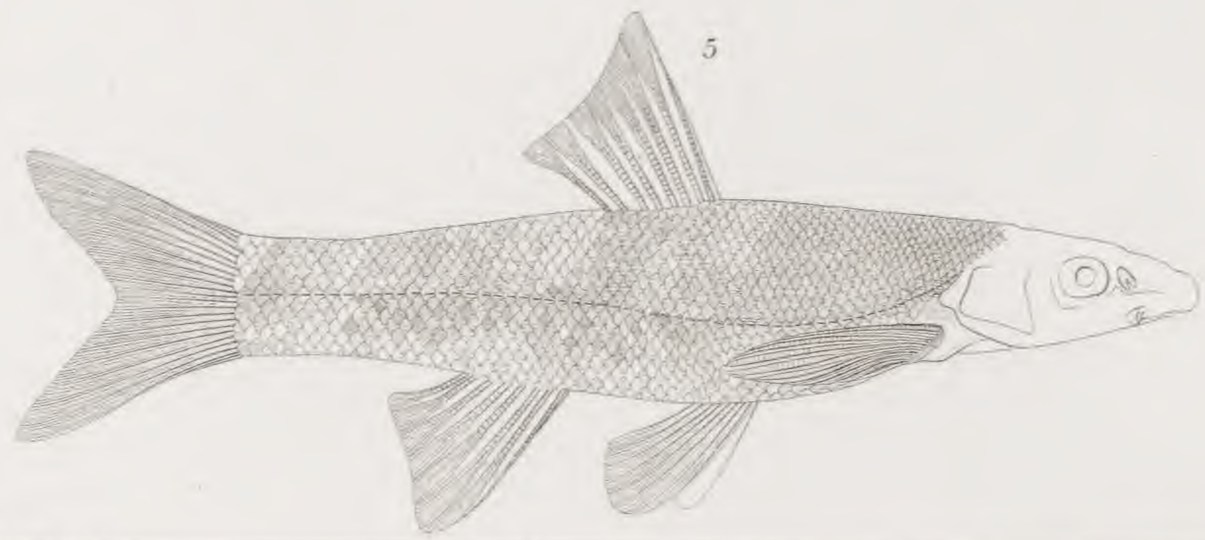
" 6. Photogenis leucops. *Cope.*













M. Peart, del.

Bowen & C° lith. Phil^a

PLATE XIII

PLATE XIII.

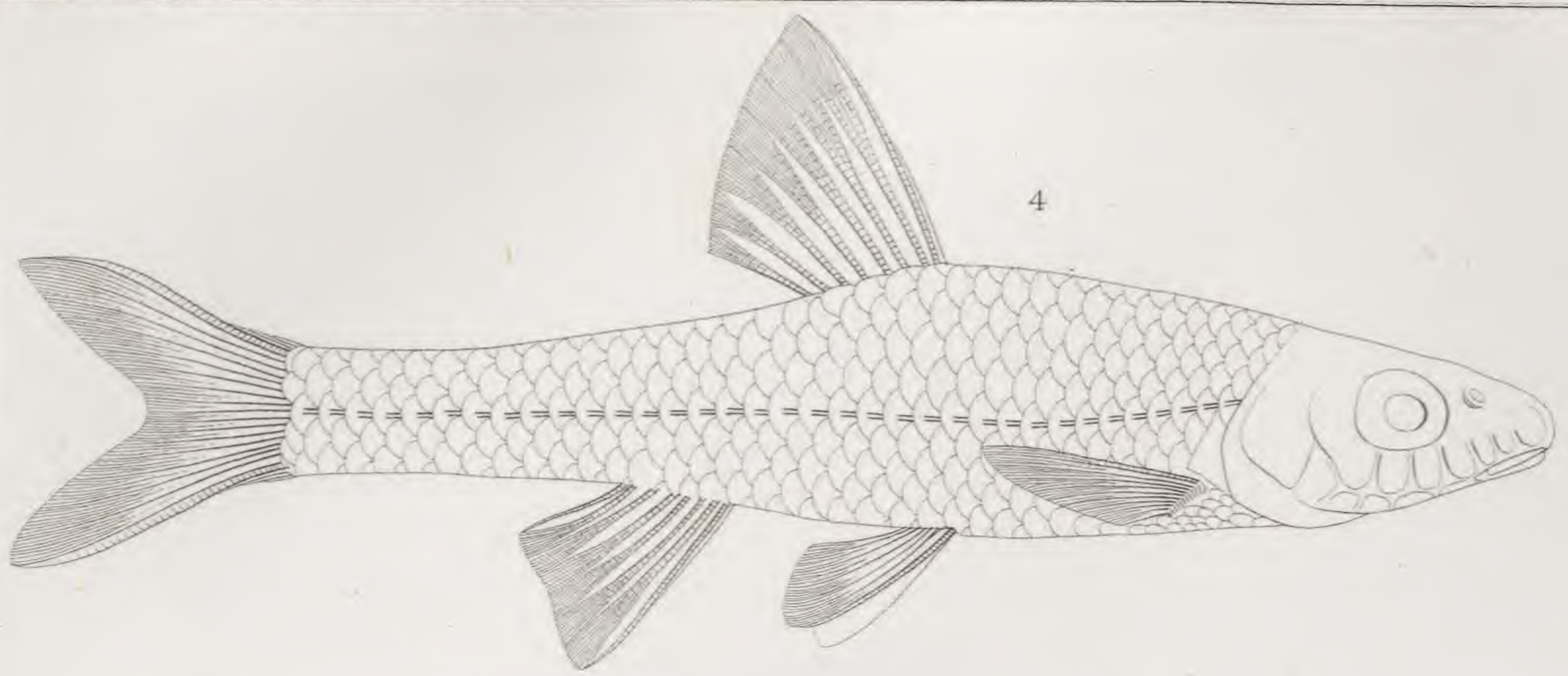
Fig. 1. CLINOSTOMUS MARGARITA. *Cope.*

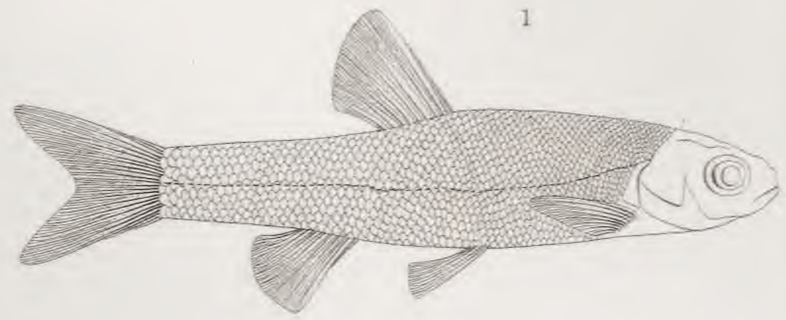
" 2. CLINOSTOMUS FUNDULOIDES. *Girard.*

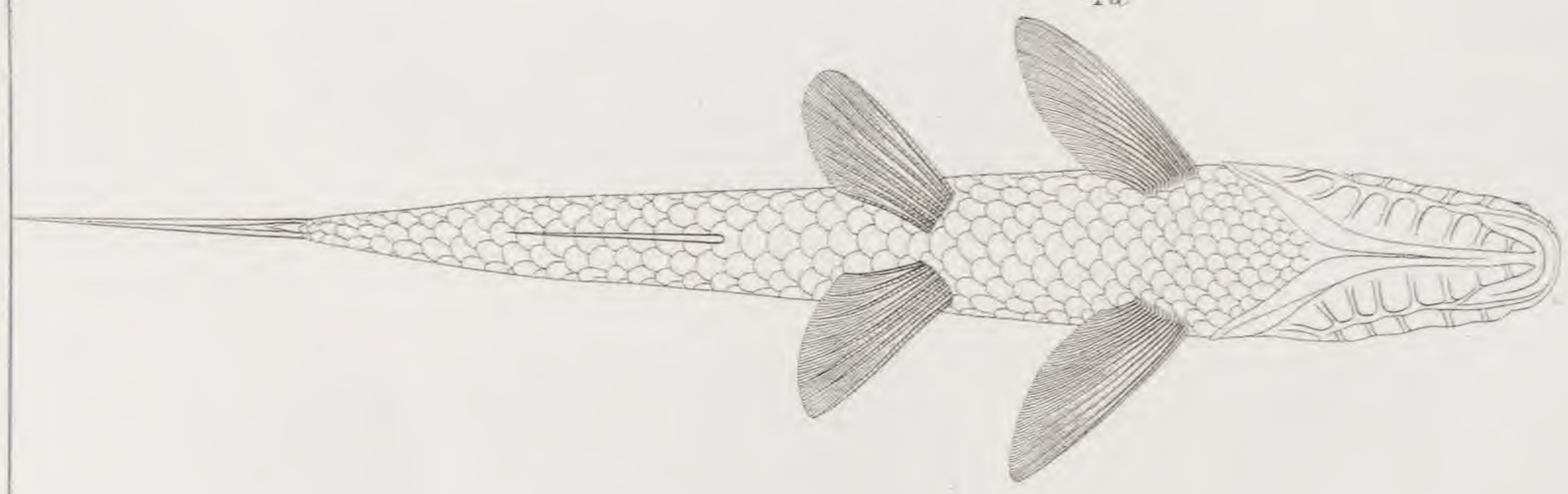
" 3. ALBURNELLUS RUBRIFRONS. *Cope.*

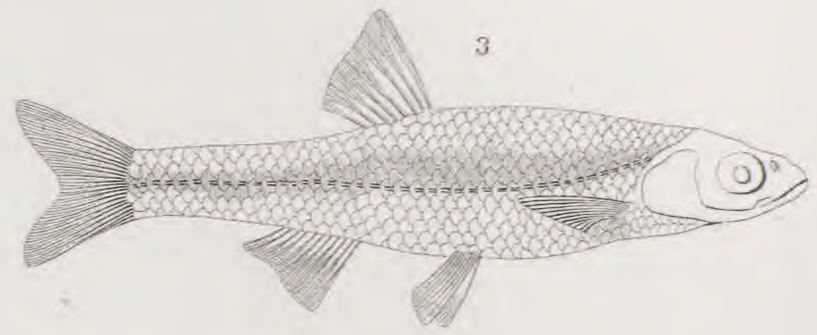
" 4 and 4 *a*. ERICYMBA BUCCATA. *Cope.*

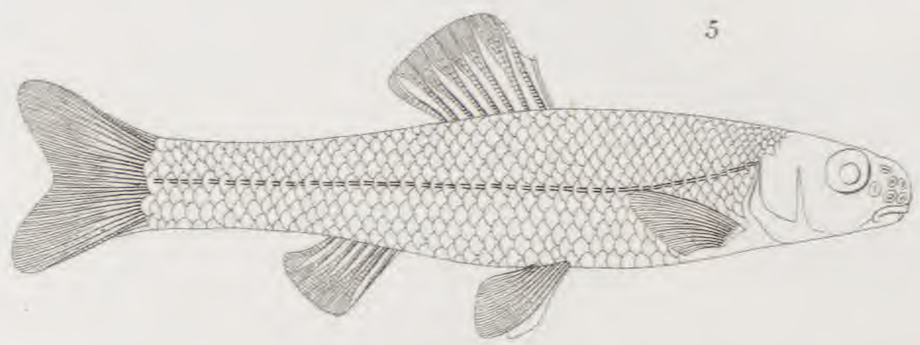
" 5. HYBORHYNCHUS NOTATUS. *Rafinesque.*

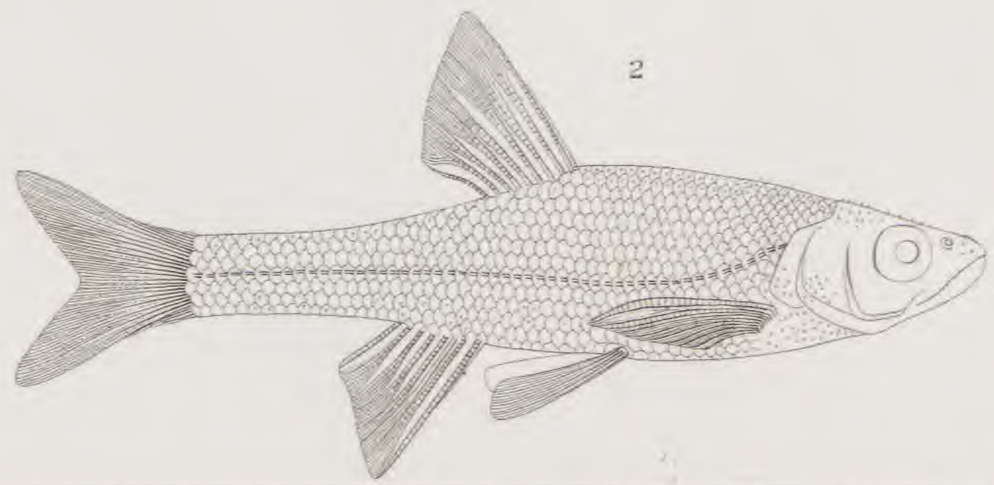












M. Peart, del.

Bowen & C° lith. Phil^a



L. Lesquereux. del.

Bowen & Cº lith. Philadª

1, 2, 3, CALAMOPSIS DANAI 4, 5, 6, SABAL GRAYANA.


1

4


3


8


7

2

5

6

L. Lesquereux, del.

Bowen & Cº lith. Philadª

1,2, POPULUS MONODON
7 SALIX WORTHENII.

3,4,5,6 SALISBURIA BINERVATA
8 ASIMINA LETOCARPA

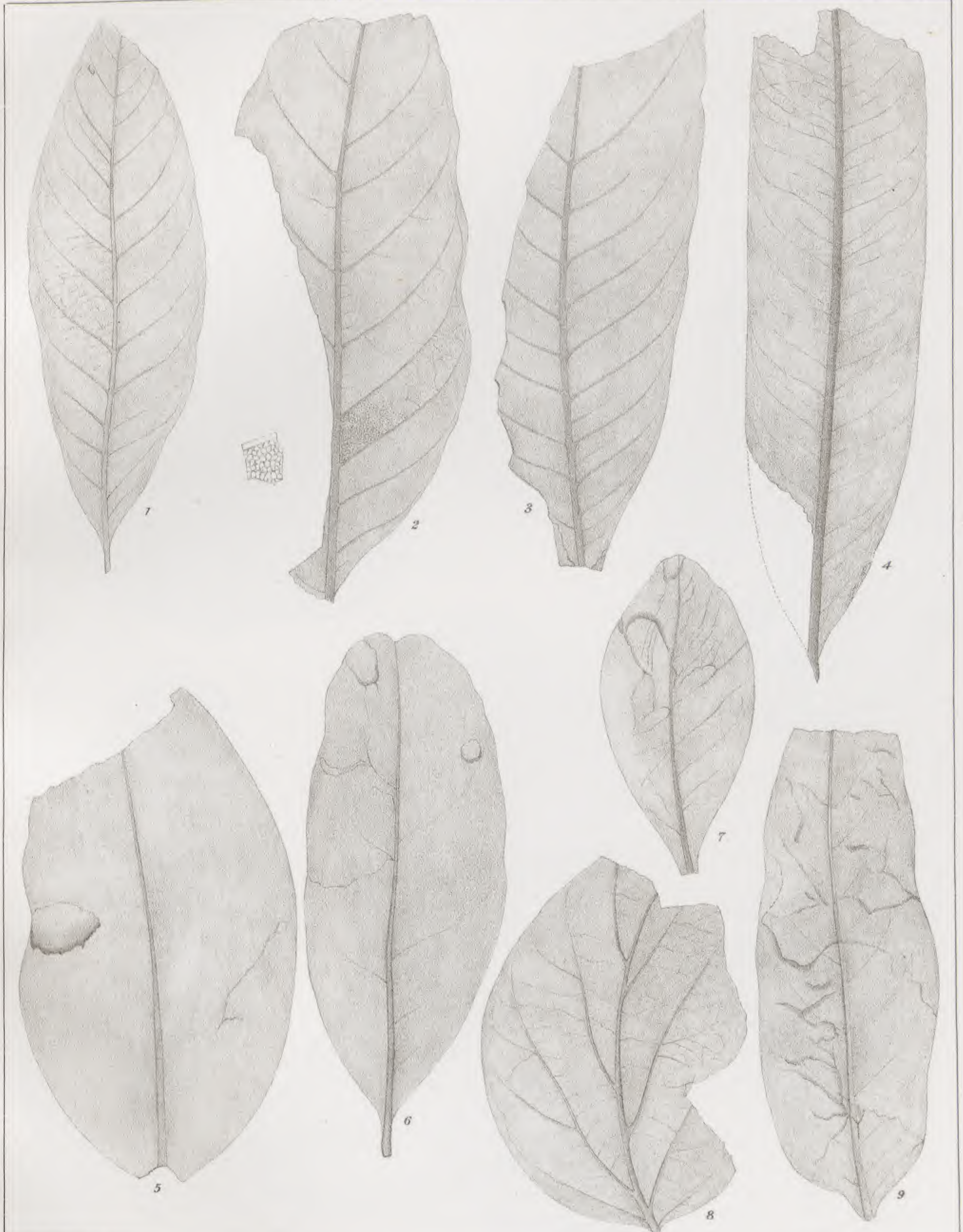


L. Lesquereux, del.

Bowen & Cº lith. Philadª

1,2,3. QUERCUS MOORII. 4,5. QUERCUS RETRACTA

6 BANKSIA HELVETICA



L. Lesquereux. del.

Bowen & Cº lith. Philadª

1,2,3 QUERCUS LYELLII
4 SALIX TABELLARIS
5,6,7 QUERCUS CHLOROPHYLLA
8 FICUS CINNAMOMOIDES
9 PHYLLITES TRUNCATUS



L. Lesquereux, del.

Bowen & Cº lith. Philadª

1,2,3, FICUS SCHIMPERI. 4,5,6 POPULUS MUTABILIS REPANDO-CRENATA



L. Lesquereux. del.

Bowen & Cº lith. Philadª

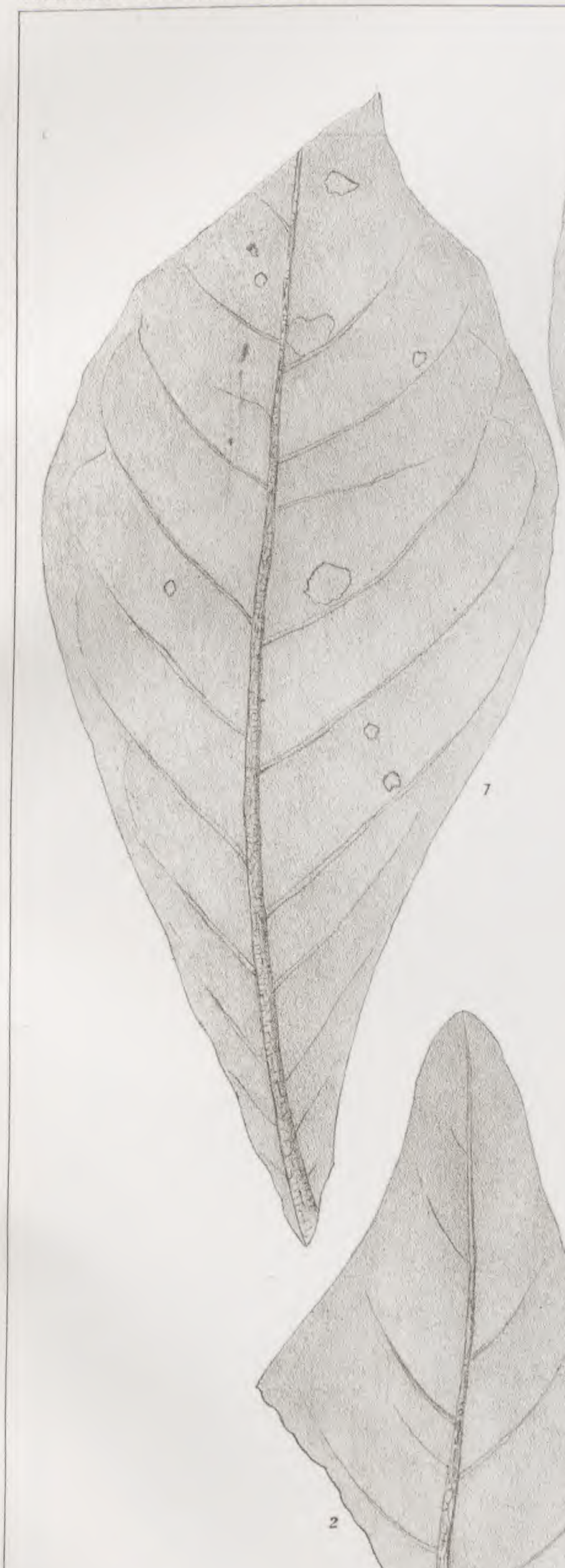
1 LAURUS PEDATUS. 2 CINNAMOMUM MISSISSIPIENSE
3, 4 PERSEA LANCIFOLIA 5, 6, 7 CEANOTHUS MEIGSII



L. Lesquereux, del.

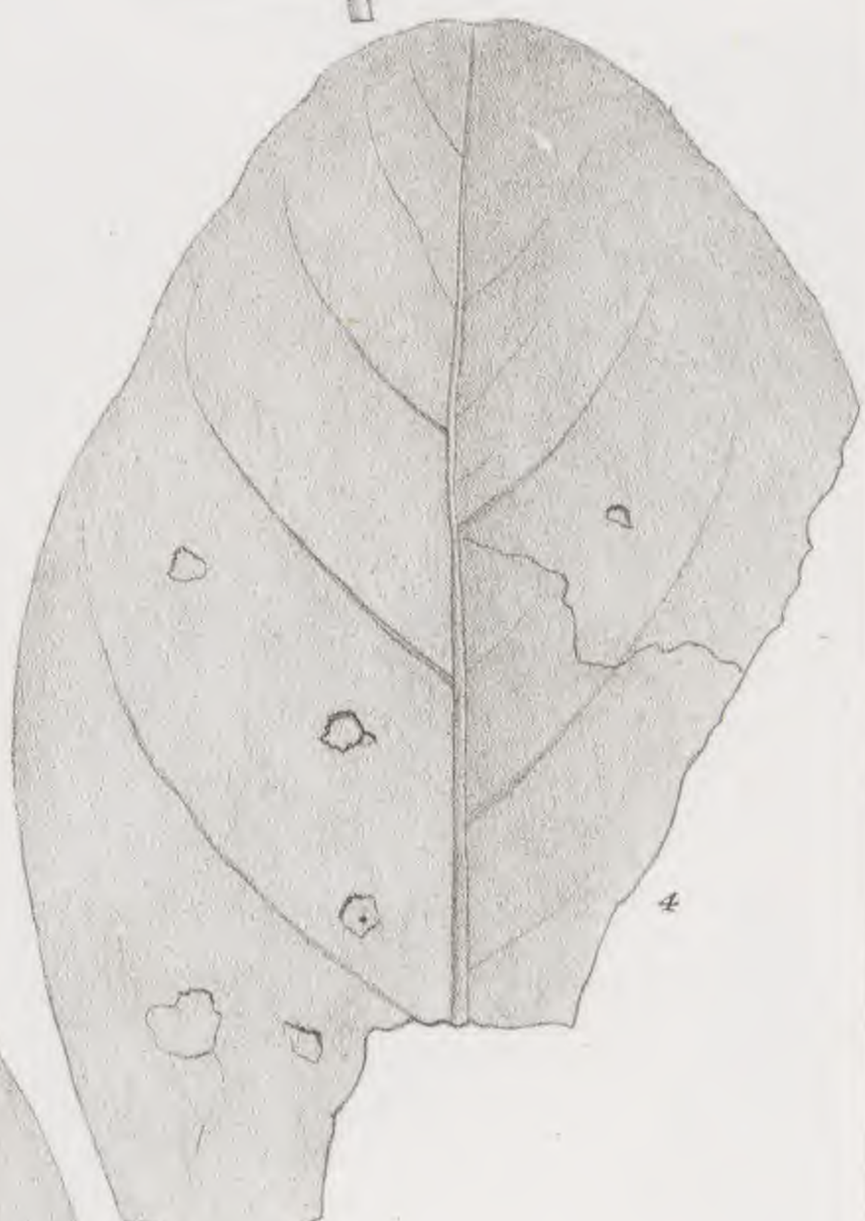
Bowen & Cº lith. Philad.ª

1 MAGNOLIA HILGARDIANA. 2,3, MAGNOLIA LAURIFOLIA.
4,5 CELTIS BREVIFOLIA. 6 JUGLANS APPRESSA
7 JUGLANS SAFFORDIANA.


1


3

2


4

L. Lesquereux, del.

Bowen & C° lith. Philad.ª

1, 2. MAGNOLIA LESLEYANA 3, 4 MAGNOLIA OVALIS



L. Lesquereux, del.

Bowen & Cº lith. Philadª

1,2. MAGNOLIA CORDIFOLIA. 3, 4, 5, RHAMNUS MARGINATUS
6. SAPINDUS UNDULATUS



L. Lesquereux, del.

Bowen & Cº lith. Philadª

1 SASSAFRAS LE CONTEANUM
2.3, POPULITES MICROPHYLLUS
4 PHYLLITES BETULŒFOLIUS
5,6,7 PROTEOIDES ACUTA
8 PROTEOIDES GREVILLIÆ FORMIS
9,10 PERSEA NEBRASCENSIS
11 ANDROMEDA PARLATORII
12. CINNAMOMUM HEERII



1



2



3

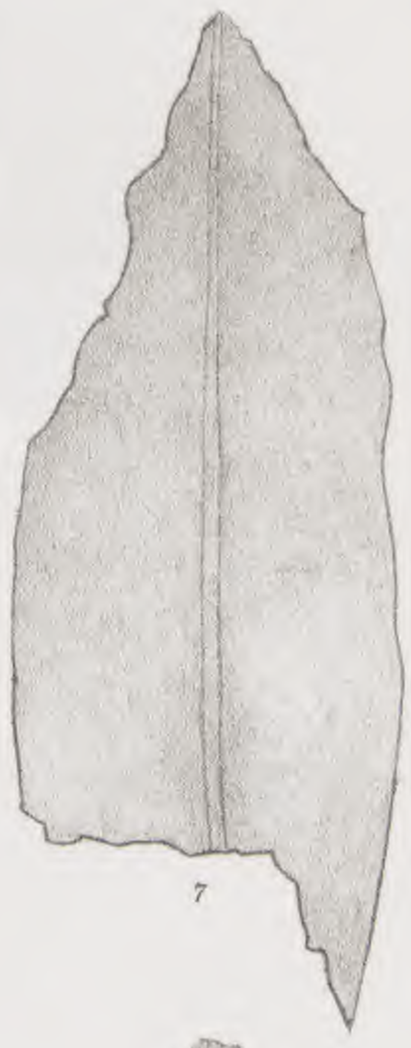
4



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7

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11



12

L. Lesquereux, del.

Bowen & Cº lith. Philadª

1 SASSAFRAS LE CONTEANUM

2,3, POPULITES MICROPHYLLUS

4 PHYLLITES BETULŒFOLIUS

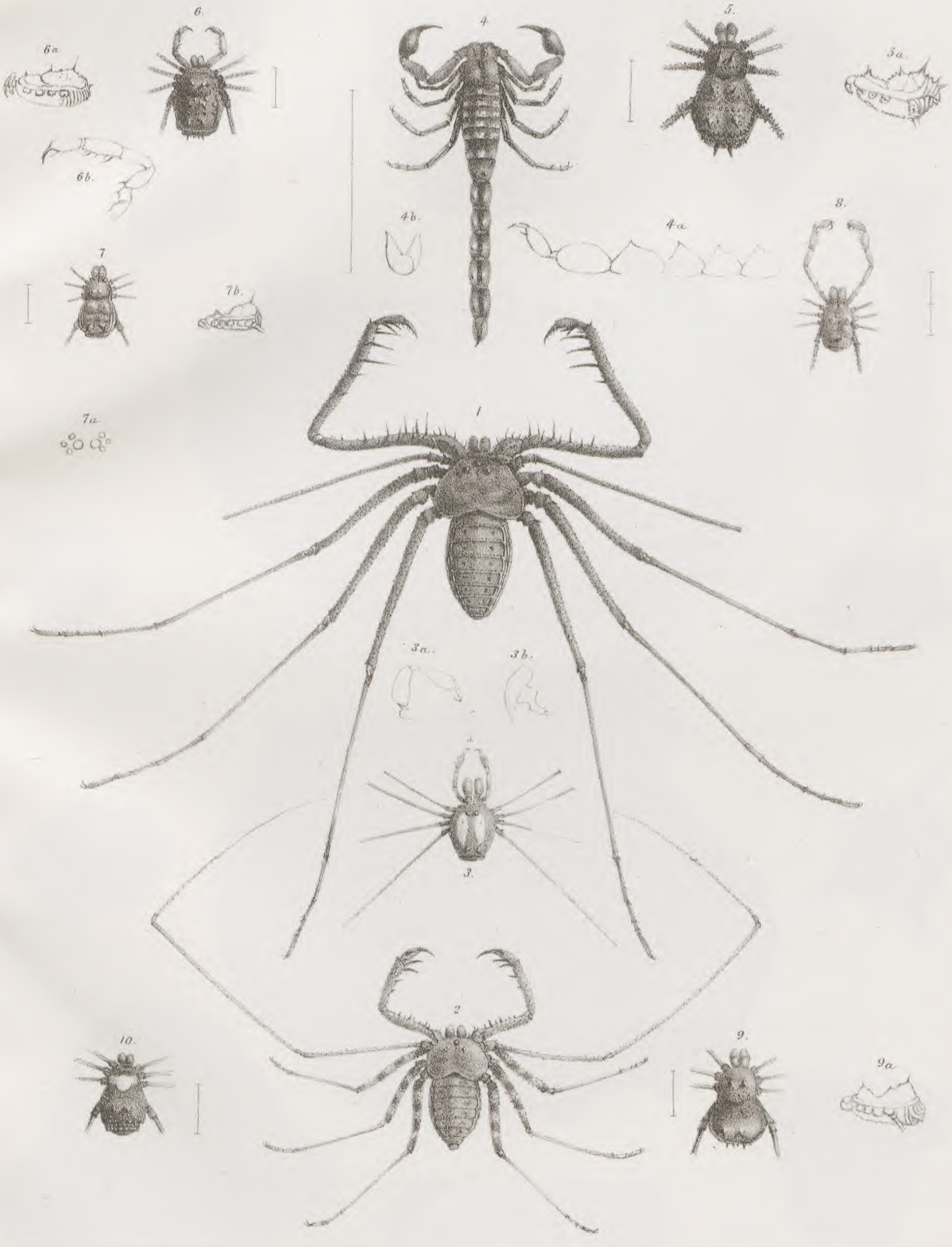
5,6,7 PROTEOIDES ACUTA

8 PROTEOIDES GREVILLIÆ FORMIS

9,10 PERSEA NEBRASCENSIS

11 ANDROMEDA PARLATORII

12 CINNAMOMUM HEERII



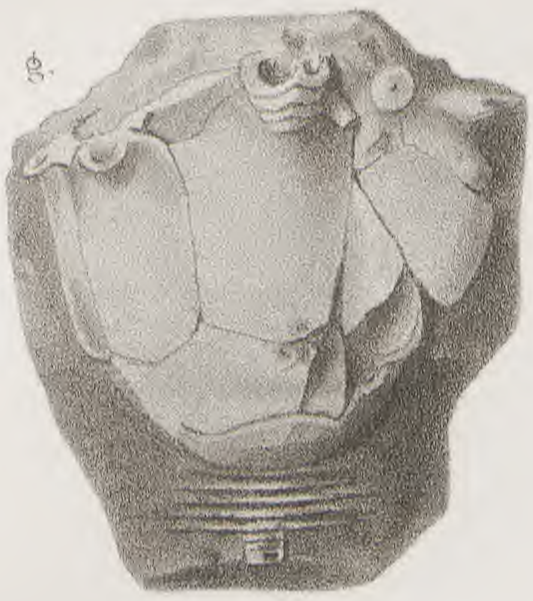
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S. S. Lyon. 1869.

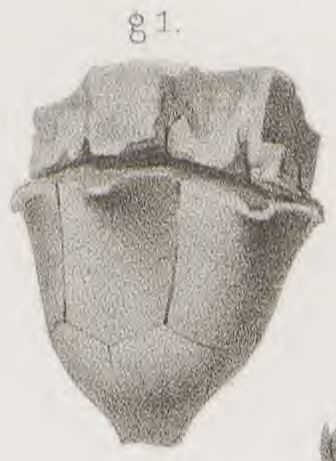
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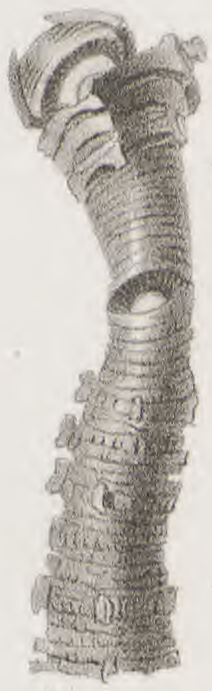
f.



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g 1.



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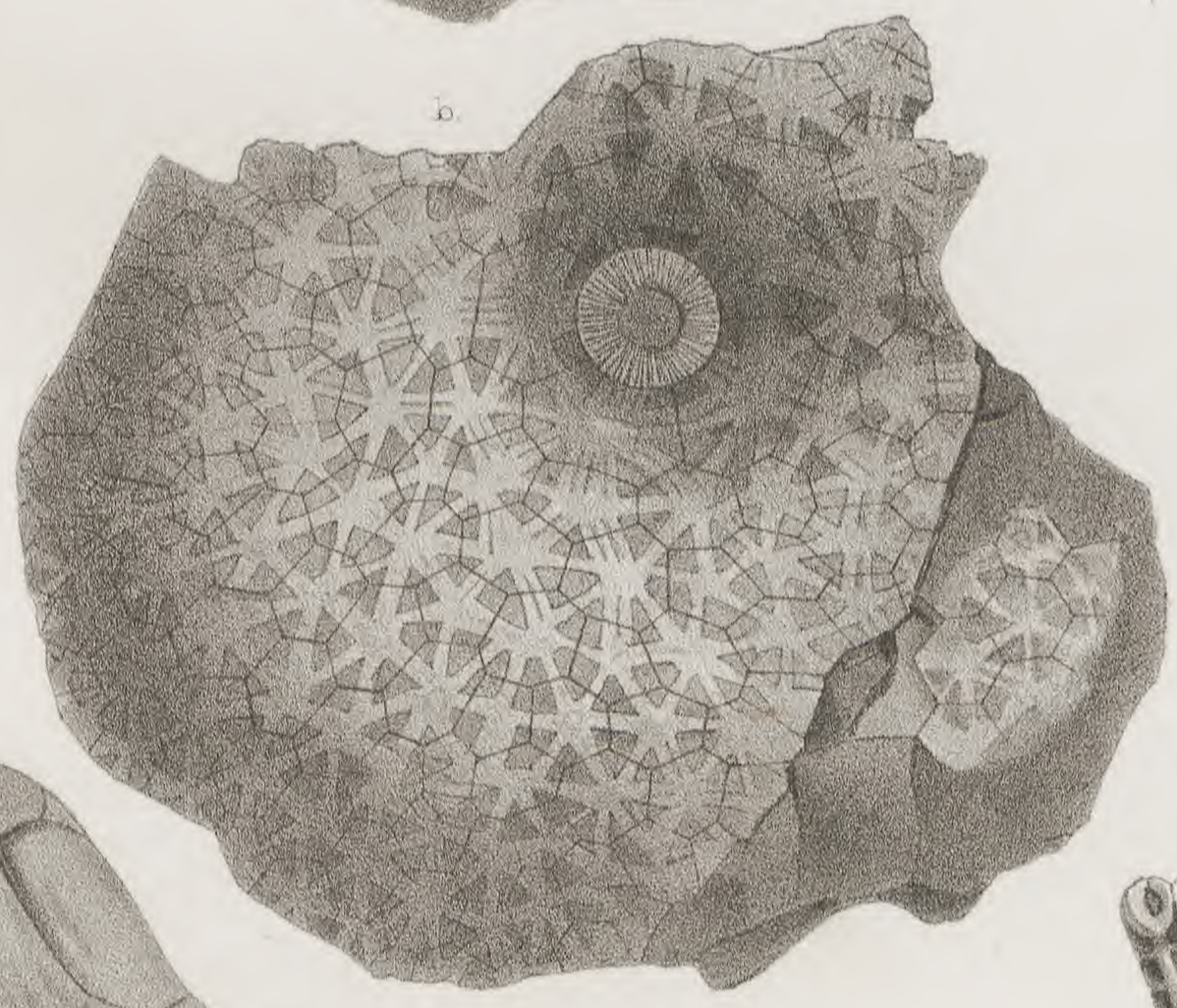
a.



e.



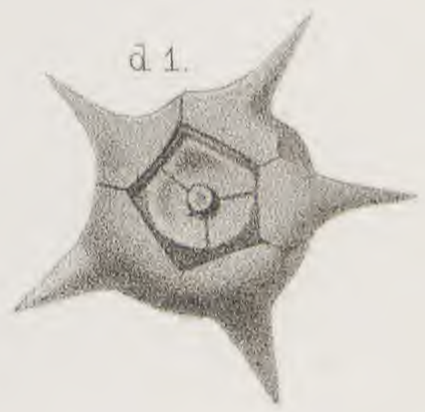
d.



b.



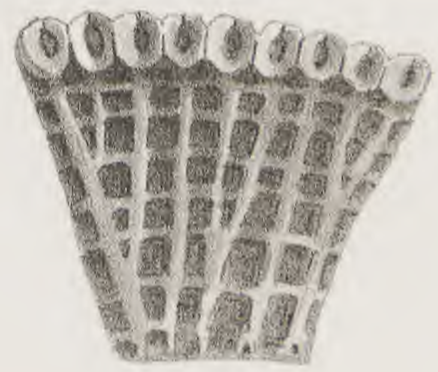
c.



d 1.



b 1.



b 3.



b 2.

CRINOIDS OF KENTUCKY AND INDIANA.

T. Sinclair lith. Phila.

PLATE II.

i. Cyathocrinus rarus. N. S.

i. 1. Cyathocrinus rarus. Different specimen.

k. Cyathocrinus tenuibrachiatus. N. S.

l. Poteriocrinus cylindricus. N. S.

l. 1. Poteriocrinus cylindricus. Reverse same specimen.

m. Zeacrinus stimpsoni. N. S.

m. 1. Zeacrinus stimpsoni. Reverse.

n. Dolatocrinus marshi. N. S. Basal view.

n. 1. Dolatocrinus marshi. Profile view.

n. 2. Dolatocrinus marshi. Summit view.

o. Ataxiacrinus caponiformis. N. S. Profile view.

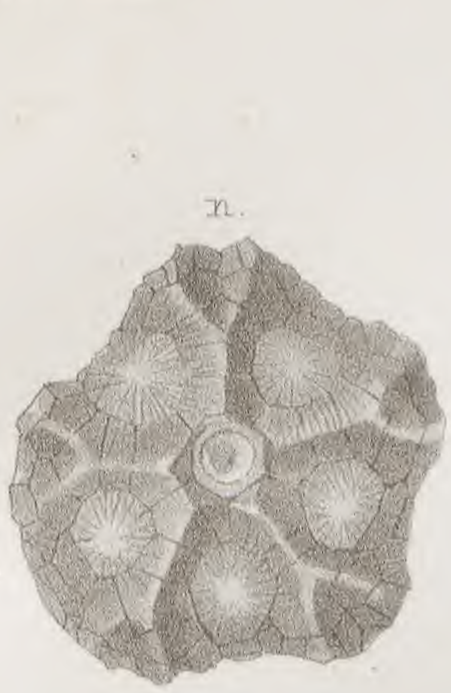
o. 1. Ataxiacrinus caponiformis. Summit view.

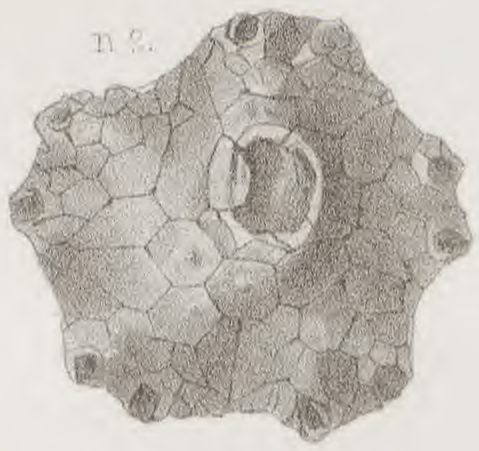
o. 2. Ataxiacrinus caponiformis. Basal view.

o. 3. Ataxiacrinus. Generic diagram.

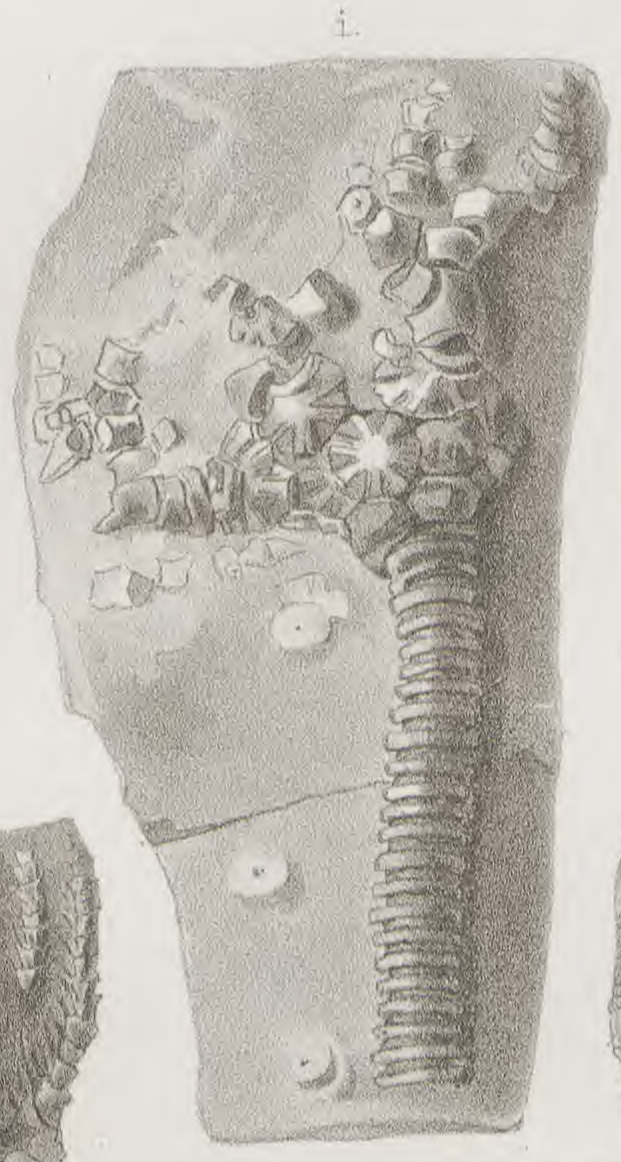
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n.


n 2.


n 1.


i.


l.


h.


k.

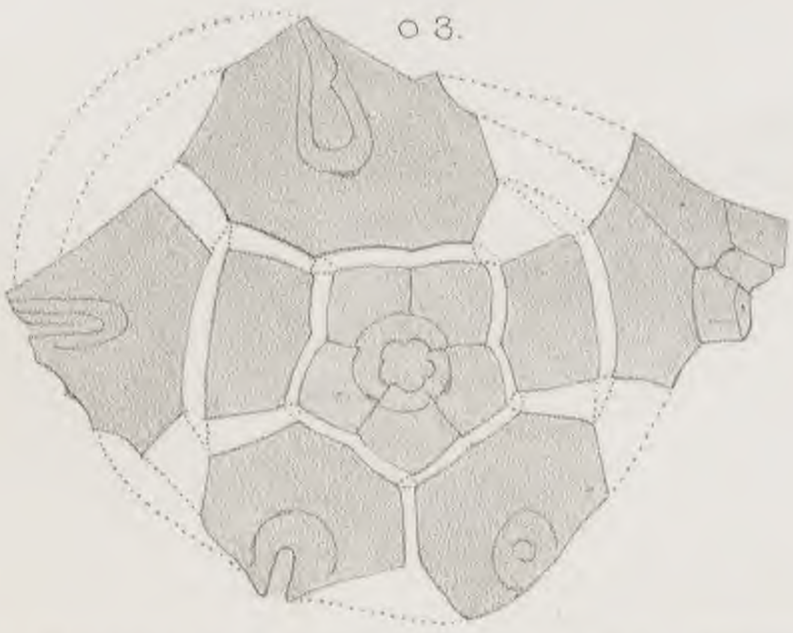

i 1.

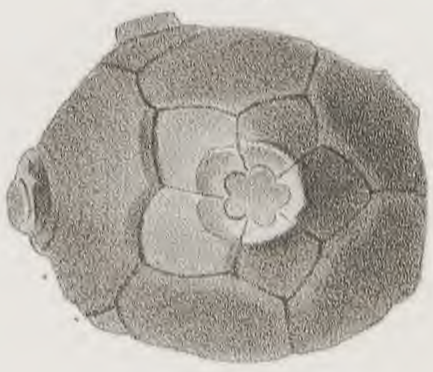

m.


m 1.


o 1.


o.


o 3.


o 2.

CRINOIDS OF KENTUCKY AND INDIANA.

T. Sinclair lith. Philada.

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ARTICLE III.—*On the Comparative Etymology of the Yoruba Language. By Pliny Earle Chase, A.M.,* . . . . . " 35

ARTICLE IV.—*Thoughts on the Influence of Ether in the Solar System. By Alexander Wilcocks, M.D.,* . . . . . " 73

ARTICLE V.—*On New Mosses. By Thomas P. James,* . . . . . " 105

ARTICLE VI.—*On the Numerical Relations of Gravity and Magnetism. By Pliny Earle Chase, A.M.,* . . . . . " 117

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PART III.

PAGE

ARTICLE VIII.—*On the Hydrology of the Basin of the River Saint Lawrence. By Thomas Evans Blackwell, M. I. C. E.* (with two plates, IV, V), ... 249

ARTICLE IX.—*Notes on a Map intended to Illustrate Five Types of Earth-surface in the United States, between Cincinnati and the Atlantic. By J. P. Lesley* (with a map, VI), ... 307

ARTICLE X.—*On Fucoides in the Coal Formations. By Leo Lesquereux* (with a plate, VII), . . 313

ARTICLE XI.—*Notes upon the Geology of some portions of Minnesota, from St. Paul to the Western Part of the State. By James Hall,* 329

ARTICLE XII.—*A Contribution to the Knowledge of the Flora of the Coal Period in the United States. By Horatio C. Wood, Jr., M.D.* (with two plates, VIII, IX), ... 341

ARTICLE XIII.—*Synopsis of the Cyprinidæ of Pennsylvania. By Prof. Edward D. Cope* (with four plates, X, XI, XII, XIII), ... 351

Supplement on some New Species of American and African Fishes, ... 400

ARTICLE XIV.—*On Species of Forest Plants from the Tertiary of the State of Mississippi. By Leo Lesquereux* (with ten plates, XIV, XV, XVI, XVII, XVIII, XIX, XX, XXI, XXII, XXIII), ... 411

ARTICLE XV.—*On the Phalangia and Pedipalpi collected by Professor Orton in Western South America, with the Description of New African Species. By H. C. Wood, Jr., M.D.* (with a plate, XXIV), ... 435

ARTICLE XVI.—*Remarks on Thirteen New Species of Crinoidea from the Palæozoic Rocks of Indiana, Kentucky, and Ohio, and a Description of certain Peculiarities in the Structure of the Columns of Dolatocrinus, and their Attachment to the Body of the Animal. By Sidney S. Lyon* (with two plates, XXV, XXVI), ... 443

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